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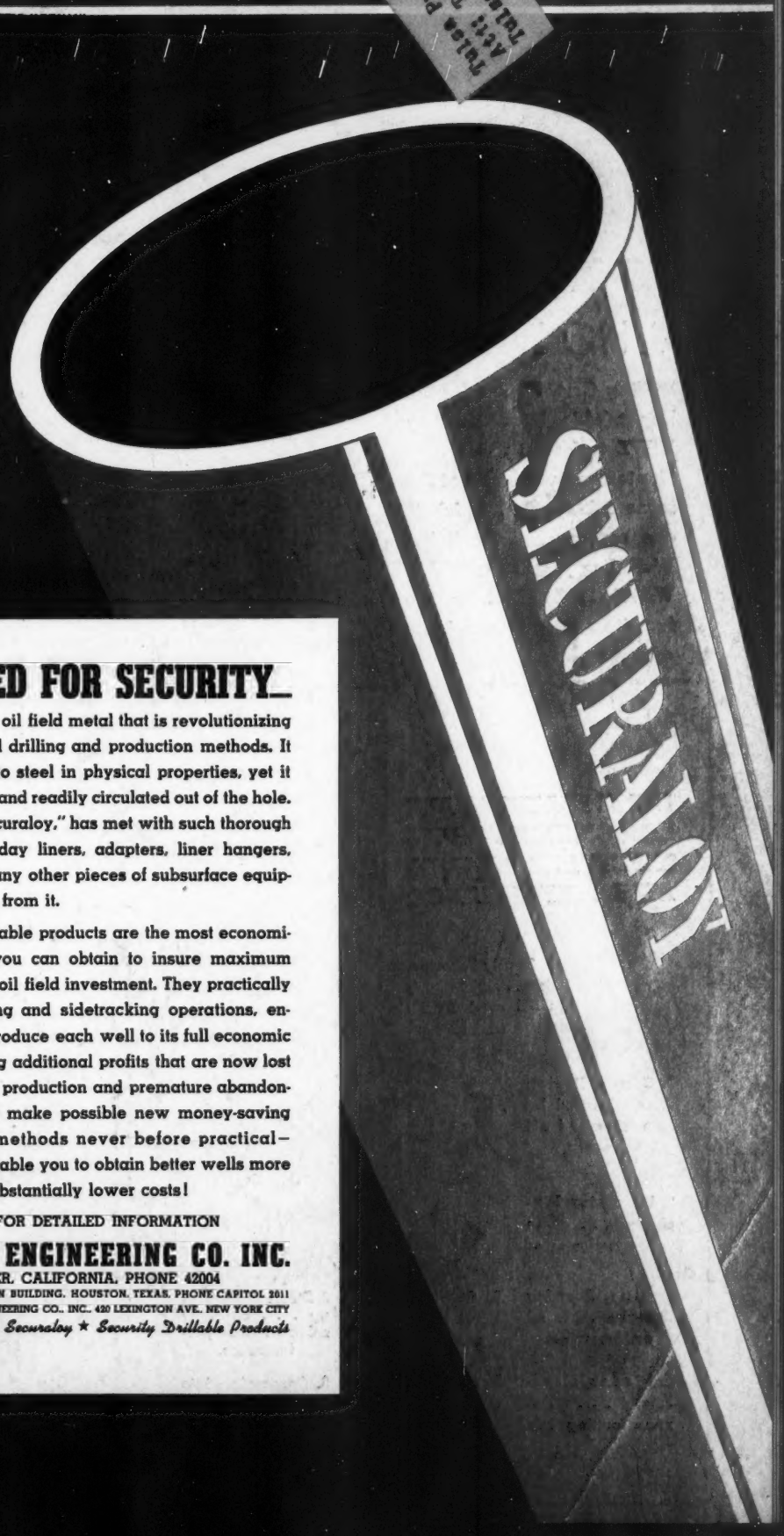

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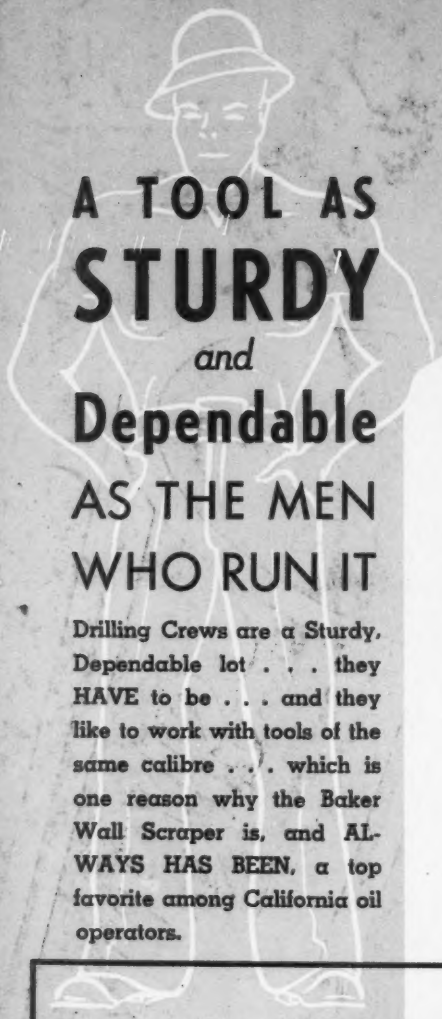
BAKER ROTARY WALL SCRAPER



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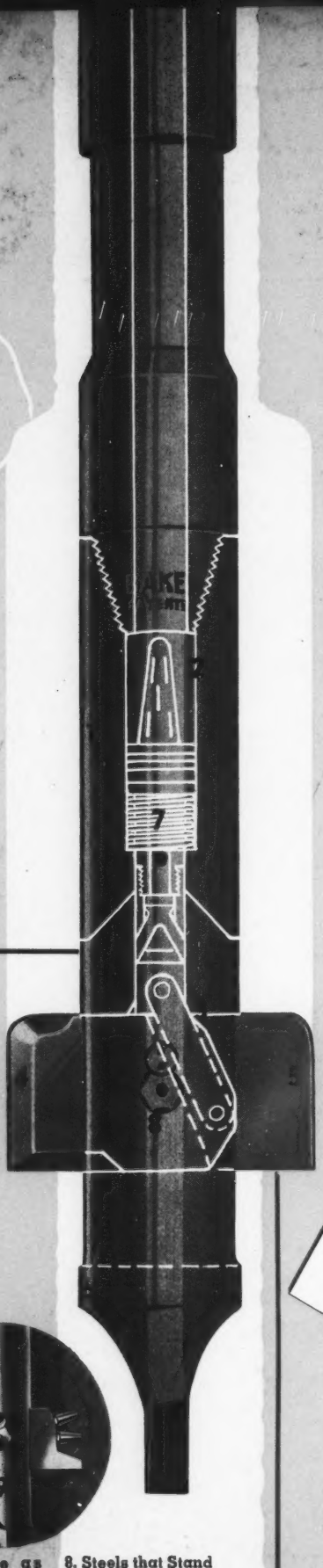

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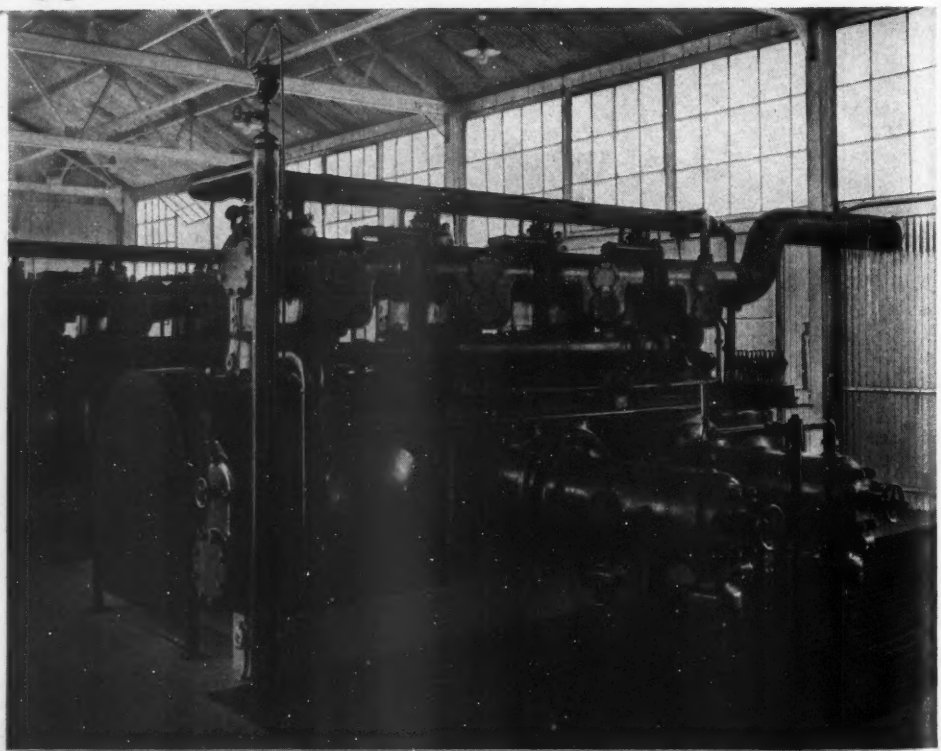

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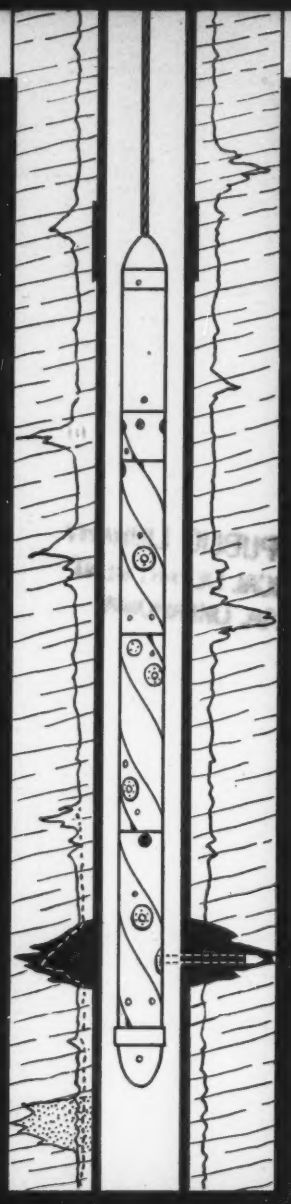

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Effects of Gas Injection in the Oil Formation

on Natural Gasoline Plant Operation

By Henry N. Wade
President, Parkhill-Wade

For the purposes of this paper I am using the term "gas injection" to cover any operation involving the forcing of gas into a producing formation for the purpose of facilitating, or increasing the ultimate total of, recovery of oil from the formation. Considering the conditions in the producing formation, the source of the injected gas is immaterial. In other words, regardless of whether the operation falls in the class of "pressure maintenance" or of "repressuring", the act of injecting gas into the formation produces the same results as far as the formation conditions themselves are concerned. Depending upon the relations between the producing factors, which have been discussed, the injection may retard the rate of pressure decline in the formation, or may stop such decline altogether, or may actually raise the formation pressure.

Although the benefits of gas injection are felt most directly in the production of crude oil, the conservation of natural gas which it affords will obviously have far-reaching effects on natural gasoline operations. These effects are of four different types, and are as follows:

1. Effect on quality of the wet gas.
2. Effect on quantity of the wet gas.
3. Effect on the life of the plant operation.
4. Effect on plant design.

These effects will be discussed in the order named:

Effect on the Quality of the Wet Gas

It is obvious that if dry gas is returned, or injected from another source, into a producing formation for a long enough time, the gasoline content of the wet gas taken from the formation will gradually decrease. If such an operation were continued until the formation had been completely stripped of its volatile liquid contents, the returned gas would of course finally circulate through the dry formation without any change in its composition. Thus the first effect we may expect is a gradual reduction in the gasoline content of the wet gas, and this general theory is supported by experience.

A Mid-Continent operator reports the following data from a field in North Central Texas. The oil pool covers about 1500 acres, and produces 41° A.P.I. oil from a sand 15 feet thick at a depth of from 1150 to 1200 feet. The structure is made up of lenses and interbedded shales, with consequent irregular porosity and permeability; thus the nature of the formation favors channeling between input wells and producers. The effect of such channeling was minimized as far as possible by careful selection and mechanical treatment of the wells. The field has no water-drive; the gas injection was used for the purpose of increasing oil recovery.

Henry N. Wade

Fig. 1 shows the operating results for the years of from 1926, just before gas injection was started, to 1931. At the beginning, only the dry gas from the gasoline plant was injected; shortly thereafter gas from an outside source was added.

The most significant points illustrated on this chart, from the standpoint of the natural gasoline plant operator, are the increase in the quantity of gasoline produced, and the lengthening of the plant operating life. In 1926 the production was at a low ebb; operation would have been discontinued in a few months. After gas injection was started the production of gasoline increased sharply, and did not reach the low level of 1926 until about 4 years later. This operation shows, on a small scale, the principal effects of gas injection in a depleted field on gasoline plant operation.

Two other gas injection operations, now 12 years and 6 years old, respectively, have each shown a gradual decrease in the gasoline content to practically 80% of the initial value. Based upon the assumption that the rate of oil production has been kept constant, these same properties have shown an increase in gas-oil ratio of about 30%, so that the gasoline production from the gas is now about 104% of the original production. The operators report that both of these gasoline plants were about to be shut down when the gas injection was started; however, due to the improvement in production caused by the injection program they are still in profitable operation.

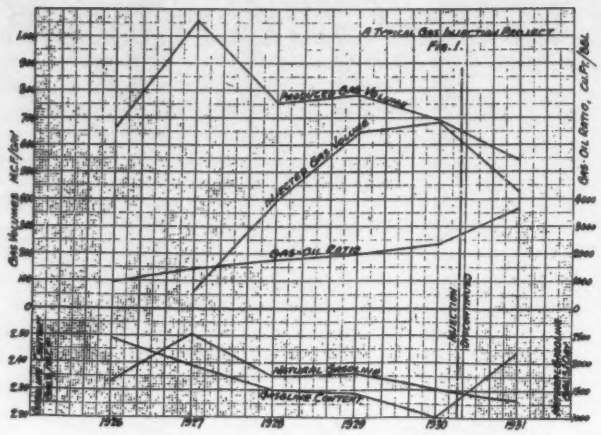
Still another operator reports a field about 15 years old, in which the gasoline plant was shut down about two years ago, on account of exhaustion of the gas. Injection of gas from an outside source was started last year, with the result that the produced gas volume has now built up sufficiently to permit profitable operation of the plant. In addition, the rate of oil production has been exactly doubled by the gas injection.

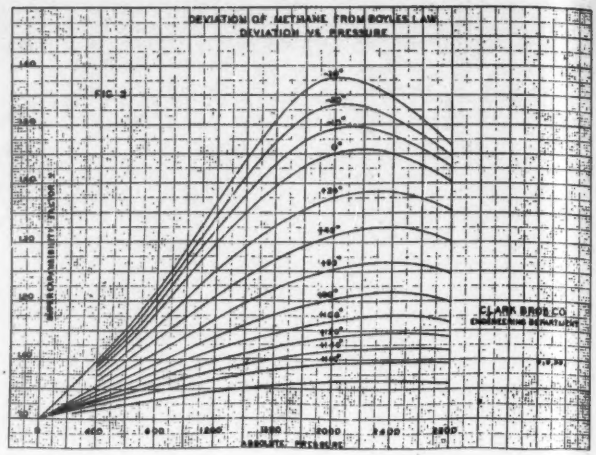
In two of the most recent applications of gas injection, respectively, about 10 months and 18 months old, no appreciable change has been observed yet in the quality of the gas produced; if anything, the gasoline content has tended to increase. This is undoubtedly due to more careful selection and management of wells, since all production has been shifted to wells showing the lowest gas-oil ratio in order to conserve compressor horsepower.

In the older of these two applications, the gasoline content of the gas, which is trapped out of the oil at about 500#/sq. in. pressure, has actually increased from 0.365 G.P./M. to 0.436 G.P./M., while the gas-oil ratio has decreased from 6,230 cu. ft./bbl. to 5,060 cu. ft./bbl. These two tendencies about offset each other, so that the gas now yields 2.205 gallons of gasoline per barrel of oil produced as compared with 2.272 gals./bbl. before gas injection was started. Thus, the gasoline plant is producing practically the same amount of gasoline from about 19% less gas, the quantity of crude oil produced remaining constant in this case. In time, of course, the normal trend toward lower gasoline content and higher gas-oil ratios will set in.

Effect on Quantity of Wet Gas Produced

It is evident that, as liquid materials are withdrawn from the formation, the injected gas will have increasing opportunity to channel or by-pass from the input wells to the producing wells through the drying formation, and that





therefore, the gas-oil ratio in the producers will eventually tend to increase. This tendency can be offset for a time by progressively taking production from wells lower on the structure, but this can be done only out to the limits imposed by edge-water.

This tendency is clearly shown in the data presented in Fig. 1, where the gas-oil ratio is seen to increase about 38% over the period covered.

From the standpoint of the natural gasoline plant operator, this tendency will at least partly offset the decline in gasoline content of the gas, so that his plant production will tend to remain nearly constant throughout the life of the field, assuming the rate of oil production is nearly constant.

Effect on Life of Gasoline Plant Operation

In all of the above discussion it is apparent that gas injection offers a means of bringing dead properties back to life, and of greatly prolonging profitable operation in a new field if pressure maintenance is started early.

Assuming that the cost of the injection operation is justified by savings and increased recoveries in the production of oil, so that no part of it is chargeable to the gasoline plant, the plant operator is automatically saved the expense of installing compressors for gathering gas until the structure is nearly completely exhausted of both gas and oil.

Finally, if the gasoline plant operator shares in the revenue from the sale of dry gas, it is obvious that the gas saved by return to the formation affords a reserve of future income which may permit profitable operation for many years beyond the time when the plant would have to be shut down if the gas were wasted.

Selection of Trapping and Gasoline Plant Pressures

The selection of operating pressure conditions will, of course, depend on the local circumstances surrounding each operation. In general, the cheapest installation will result if a maximum of gas is separated from the oil at the highest possible pressure, since the suction pressure at the compressors determines the horsepower required to pump a given volume against a fixed discharge pressure. For example, assume that the wells produce with a gas-oil ratio of 5,000 cubic feet per barrel, and show a well-head pressure of 2000 pounds per square inch. The primary trap pressure might be 1500 pounds per square inch, in which case something like 4,000 cubic feet of gas per barrel would be taken out of the mixture at this pressure, leaving only about 1,000 cubic feet per barrel of gas to be removed by separators at lower pressure. The compressor horsepower required to pump this 80% of the total gas from 1500# suction to the injection pressure of say 3000#, would be only about 40% of that required to raise it to the same pressure if the primary separation were made at 600#.

In this connection I should mention that the phenomenon of "retrograde condensation" may prohibit the use of primary trap pressures much over 1000#, unless for economic reasons there is no objection to stripping the oil of some of its lighter liquefiable fractions and returning these materials to the formation. As a matter of fact, such return may actually be desirable for the purpose of reducing the viscosity of the oil in the formation, and thus facilitating its flow to the producing wells. "Retrograde Condensation" simply means that above certain limits of pressure the familiar tendency of vapors to liquefy with increasing pressure reverses itself, so that increasing pressure beyond these limits causes more and more useable liquid to remain in the gas. Thus, under normal trap temperatures, the liquid content of gas separated from a given oil at, say 1500# pressure, will be higher than the content of the gas separated from the same oil at the same temperature, but at, say 600# trap pressure. This effect varies with the composition of the gas-oil mixture, and with the temperature of separation. So far there is no exact method for calculating the magnitude of the effect, even if the gas-oil composition is accurately known; hence, it must be determined by tests. An excellent article on this subject was published in the September, 1937, issue of Industrial and Engineering Chemistry, by D. L. Katz and K. H. Hachmuth.

In the example under discussion, the oil from the primary separation would be run to a secondary separator at lower pressure, where most of the solution gas would be removed and processed through the gasoline plant. The pressure of this secondary separation might be determined by requirements for delivery to a pipe-line for sale; otherwise, it would be selected to give a satisfactory and economical operating pressure for the plant, in the range of, say 150 to 500 pounds. It might then be necessary to pass the oil through one or two additional separators at successively lower pressures, in order to reduce the gas content and vapor pressure of the oil to a point sufficiently low to prevent unreasonable storage and handling losses. The vapors from these low-pressure stages would, of course, be recovered for extraction of gasoline. As a final complication, particularly with high-gravity oils, it may be necessary to pass the crude through a stabilizer to remove excess butane and propane, in order to give it a satisfactory vapor pressure.

Depending upon local market and producing conditions, the scheme of production just outlined can obviously be rearranged in many ways. For instance, if the natural gasoline content of the gas is low, and the crude gravity also low, the viscosity-cutting effect secured

by returning wet gas to the formation may be more valuable than the gasoline which might be produced. In such a case the gas would simply be pumped back without treatment. Here, also, the principle of separating as much gas as possible at the highest pressure possible will lead to the cheapest installation.

Compressor Horsepower Requirements

At pressures in excess of about 600 pounds per square inch the so-called "Super-Compressibility" or Boyle's law deviation begins to become noticeable in its effect on compressor horsepower; this effect reaches a maximum at pressures around 2500 pounds per square inch, and then decreases at higher pressures until it practically disappears at pressures in the neighborhood of 4000 pounds. The effect of the deviation is to increase the amount of gas which can be pumped by a given amount of horsepower, since a given quantity of gas occupies less space at the higher pressures than the uncorrected application of Boyle's law would indicate. Exact methods of figuring the magnitude of this effect have not been worked out, and no practical information from high-pressure indicator cards is available yet.

Figure 2 shows the theoretical effect of Boyle's law deviation at various temperatures and pressures up to 2800 lbs. per square inch, when working with pure methane. The deviation of all the other gases of the paraffin series is greater than that of methane, hence the data of Figure 2 may be taken to conservatively represent the horsepower advantage due to deviation with any usual gas. In Figure 2 the deviation is presented as a "Super-expansibility Factor", which is the inverse of Super-compressibility Factor. The chart may be used to estimate the effect of deviation in the following manner:

Assume the compressor is to pump gas from 1200# absolute with 80° F. suction temperature to 2400# absolute discharge pressure. Use of one of the common methods for estimating the compression temperature rise indicates a discharge temperature of about 180° F. under these conditions. From the chart, the "Y" factor is 1.138 for 1200# and 80°, and 1.062 for 2400# and 180°. The deviation effect during the compression stroke will be close to the average of these figures, or 1.100. This means that a compressor horsepower will pump 1.100 times as much gas through this range of pressure as it would through a low-pressure range of the same ratio, where the deviation effect is negligible. This method is only an approximation, but it appears to give results which agree reasonably well with experience to date. It should perhaps be pointed out that the effect of deviation just discussed is in the nature of a correction to be applied to the usual methods for figuring compressor horsepower within pressure ranges wherein deviation is not appreciable; such methods are available in handbooks and in data published by the various compressor manufacturers.

High-Pressure Compressor Installation and Operating Costs

Compressor plant installation costs will, of course, vary over a considerable range according to the size of the installation, operating pressures, and types of auxiliary equipment used as determined by the expected life of the plant. Recent figures on several gas injection projects involving final discharge pressures ranging from 1200# to 4700# indicate that installed costs per horsepower will run from 10% to 20% higher than in plants where the maximum pressure is not over 500 or 600 pounds. For example, a recent 1500 H.P. plant designed to pump gas from 30# to 250# showed an installed cost of about $90 per horsepower. Another 2400 H.P. plant to pump from 1200# to 3000# cost practically $109 per horsepower. Both of these installations include an "indirect" or closed cooling system, employ angle-type compressor units, and are otherwise quite similar in general standards of construction. The increased cost of the high-pressure installation is caused chiefly by the greater cost of the high-pressure piping and valves, and of the forged-steel compressor cylinder construction.

Operating costs per installed horsepower should run little, if any, higher for a high-pressure plant than for a low. Experience with extreme high-pressures is still too limited to yield any good figures on this point. A recent careful analysis of operating cost, based on extensive experience with low-pressure plants combined with what data is now available on high-pressure operation, yields the data shown in Figure 3. The plant contains 2400 H.P. of machine capacity, and compresses 10,000,000 cubic feet per 24 hours from 30# gauge intake to 1500# final discharge. Similar figures for a variety of plant sizes and pressures are presented in Figure 4. The first two sets of figures in Figure 4 show the effect of plant size on operating cost per MCF compressed through the same ratios; the other figures show the effect of various compression ratios.

Piping Standards and Safety Provisions

It is self-evident that every possible care should be taken in the design of piping systems, and the actual execution of the work, to guard against mechanical failure when dealing with gas at any pressure. This is particularly true when working with gas injection pressures, since in addition to the hazards from fire which surround any gas operation, terrific mechanical destruction may be produced by the gas itself. It is an interesting fact that so far the accident record of extreme high-pressure gas installations is clean, which simply indicates that with proper design and execution of the work, combined with careful operation, such installations need not present any unusual hazard. The following remarks cover miscellaneous points of design based on my own experience with high pressures.

For the general design and selection of pipe, flanges and fittings, the present American Standards Association Piping-Code has proven perfectly satisfactory. I believe this Code is perhaps over-conservative in requirements for pipe thickness, but this is a good fault.

We have found the grooved flanges with soft iron ring gaskets very satisfactory for pressures up to 4700#, which is the limit of our experience. Incidentally, the static test pressure on the piping system on this job after it was completed was 7200#. In designing piping where these flanges are used, it should be kept in mind that a joint cannot be broken unless there is an end-play between flanges of about ½" to ¾", depending on size, to permit dropping out the gasket ring.

Lubricated plug cocks have proven most satisfactory as valves for high pressures; we ordinarily use the worm or spur-gear operated types for sizes above 4".

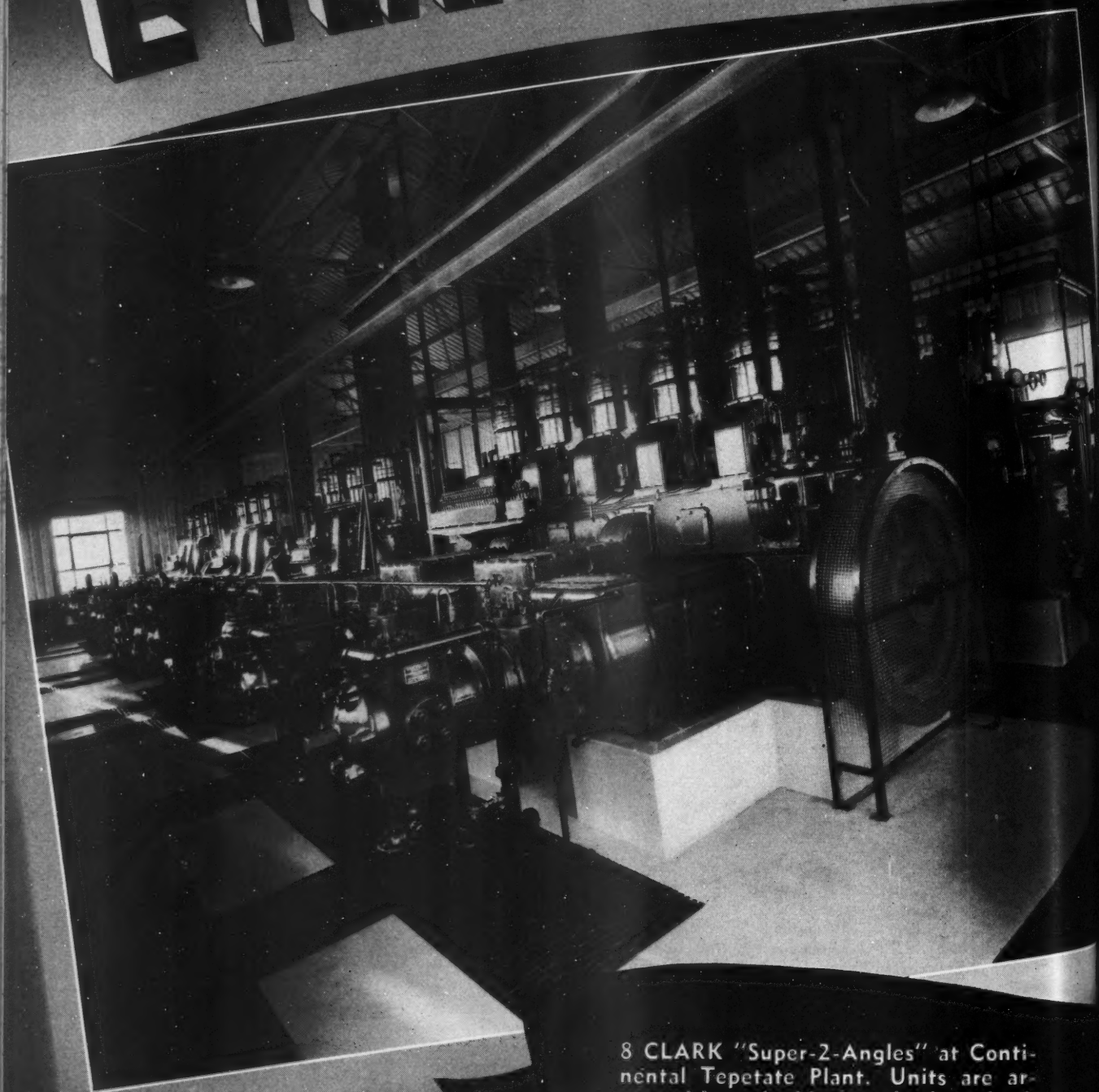
Check valves should be installed in each compressor discharge branch, and in the main discharge line outside the plant area if practicable.

Expansion and contraction strains in the piping due to operating temperature changes should be carefully studied, and provisions made to take care of them without throwing undue strains on connections to the compressors. This applies particularly to the discharge piping, since the gas is ordinarily not cooled after compression. Strain relief requires rigid anchorages at certain

FIGURE 3
COST OF COMPRESSION FOR A 2,400 H.P. PLANT
Compressing 10,000 M.C.F. per 24 Hours from 30 lb./sq. in. to 1,500 lb./sq. in.

	Cost Per 24 H.P. Hour
Operating Labor (3 men @ $8.75 and 3 @ $7.25 per day	$ .0200
Lubricating oil @ 40c per gallon	.0040
Water and Water Treatment	.0005
Lights	.0007
Fuel @ 5c per 1,000 cu. ft.	.0120
Repair and Maintenance Labor	.0070
Repair and Maintenance Materials	.0035
Miscellaneous Supplies	.0004
Auxiliary Pump Power	.0010
Total Cost per 24 H.P. hr. Including Fuel @ 5c per 1,000 cu. ft.	$ .0491
Total Cost per 24 H.P. hr. Excluding Fuel	$ .0371

2 YEARS at 2600



8 CLARK "Super-2-Angles" at Continental Tepetate Plant. Units are arranged in a double row, back to back

to 3500 POUNDS

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The plant was equipped with four CLARK 300 H.P. "Super-2-Angle" Compressors, which were capable of returning to the formation 10,000,000 cu. ft. of gas per day, at pressures up to 4,000 pounds. In fact, these units have been operated with entire satisfaction,—on a test,—up to 4,600 pounds. Prior to that time no attempt had been made to return gas to a producing zone at above 3,000 pounds.

During their two years of continuous operation at pressures ranging from 2,600 to 3,500 pounds, the four CLARK "Angles" have given highly satisfactory service. As a result of their excellent performance, two more 300 H.P. units were soon added to increase the capacity of the plant; and recently a further addition of two 5-cylinder 500 H.P. CLARK "Angles" was made. The plant now contains 8 CLARK "Angle" machines, totaling 2,800 H.P.

The Continental Oil Company is probably the outstanding pioneer in pressure maintenance. It is estimated that Pressure Maintenance, at Tepetate, will increase the ultimate oil recovery of the pool by at least 40%. The plant investment required to accomplish this increase is estimated to represent only 5% of the value of the added production.

Write us for booklet giving the history of Pressure Maintenance and its results to date, and the outstanding record of CLARK Compressors in this pioneer field.

CLARK BROS. CO. . . . Olean, N. Y., U. S. A.

Smith-Booth-Usher Co.

LOS ANGELES, CALIF., PACIFIC COAST DISTRIBUTORS

CLARK

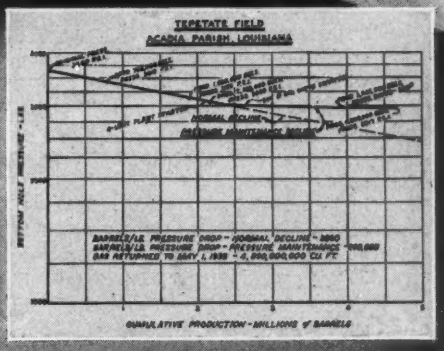
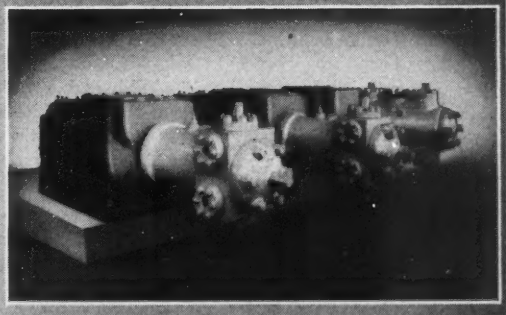
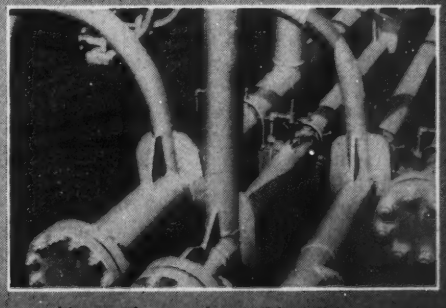


Chart shows how graph of normal decline in pressure "flattened out", when Pressure Maintenance plant was placed in operation



CLARK high-pressure cylinder used for second stage of compression. Barrel and head are forged from single steel billet



Note, above, the weld-reinforcing with gusset plates, for handling the pressures from 2,600 to 4,600 pounds

points to prevent creeping, sliding anchorages at other points to permit expansion but prevent vibration, and bends or expansion loops spaced as required to prevent accumulated strains. Expansion of headers between machine centers can be cared for by making the branches long, or by forming vertical loops in them.

We favor the installation of all piping above ground, including field lines as far as possible. This is ordinarily done by supporting the pipe on substantial concrete piers, with heavy sliding or tight clamps to hold it down. Such construction is little, if any, more expensive than burying, and it eliminates the possibility of failure through external corrosion.

For connecting branch lines into a header, we have found miter welds covered with a standard reinforcing saddle, which is welded to header and branch, more satisfactory than the welding tee fittings.

When installing vent connections from safety valves, bursting discs, or other high-pressure sources, the possible reaction forces at the vent opening must be provided for. A 3" vent, blowing 3000# gas wide open, may exert a reaction force of over 21,000 lbs.; obviously such a vent must be properly supported to withstand this force. If screwed vent valves of any kind are used, the vent piping on the discharge side of the valve must be arranged so that the reaction cannot possibly unscrew the valve from its mounting.

We have used electric arc welding with coated rod for all pipe welding as far as possible. The welds are laid in beads not over ⅛" thick, with thorough peening between beads. With such procedure it is usual to have the entire piping system pass the final hydrostatic test without a single weld leak.

On account of the extreme destruction which can result from failure of any part of the high-pressure plant piping system, special emergency shut-off arrangements should be provided. In one plant now under construction such a system is arranged so that all sources of gas can be cut off by operating any one of four small plug-cocks, which are placed at strategic points around the plant. Piston-operated plug cocks are installed outside the plant fence in both incoming and outgoing main lines. Opening any one of the four emergency control valves will simultaneously close both these main cocks, blow down the pressure on the piping within the plant through a 3"diaphragm valve, and shut down the engines. The emergency controls are located in the compressor house, the office, at the plant gate, and at a point some distance outside of the fence.

FIGURE - 4
COMPRESSOR PLANT OPERATING COSTS

Plant Capacity B.H.P.	Plant Capacity Mcf/day	Number Compression Stages	Intake Pressure lb./sq.in.	Discharge Pressure lb./sq.in.	Compression Ratio R	Cost of Compression Fuel @ 0¢ Per Mcf	Cost of Compression Fuel @ 5¢ Per Mcf
1,200	10,000	2	400	3,000	7.26	0.400	0.544
1,500	10,500	1	400	3,000	7.26	0.475	0.647
1,200	9,000	2	400	4,000	9.68	0.445	0.605
1,200	11,400	1	460	2,500	5.29	0.362	0.492
2,400	10,500	2	30	1,500	33.70	0.765	1.041
1,200	9,000	2	150	1,500	9.18	0.440	0.600

Hydrate Formation at High Pressures

It has long been known that natural gas components form loose chemical compounds or "hydrates" with water, which hydrates freeze into ice-like solids at temperatures above the freezing point of water; and that the freezing point of the hydrates rises with increasing pressure. The behavior of a typical gas in this respect has been given by Hammerschmidt in Industrial & Engineering Chemistry, Vol. 26, 1934, Page 851. Hammerschmidt's curve and formula have been checked many times by experience, and may be taken to apply with reasonable accuracy to any usual composition of natural gas. Within my own experience I have seen hydrates form and partially plug pipe lines under the following approximate conditions: 42° F. at 250# ga., 54° F. at 420# ga., and 80° F. at 4000# ga. Thus there is real danger of hydrate formation at normal temperatures in lines handling gas for gas injection.

Hydrates form only if the gas is at least saturated with water vapor under the conditions of temperature and pressure prevailing, hence their formation can be prevented by dehydrating the gas. Under most circumstances this would be impractical, and the only feasible way of preventing their formation is to keep the pipe line temperature above the temperature of hydrate formation. Under California conditions the heat of compression will ordinarily take care of this. At the Tepetate plant it was necessary to insulate part of the return line in order to conserve the heat of compression. In extreme cases it might be necessary to apply heat to parts of the line remote from the plant. This could best be done with a hot water or steam jacket on the line, in order to avoid danger of overheating the pipe.

Effect on Plant Design

In considering a new plant, the tendency of the gas to become leaner and to increase in volume should be kept in mind. Since a long life can be expected, the operator would be justified in selecting a plant somewhat over-designed for immediate requirements, so as to have some reserve for gas-handling and oil-circulating capacity. In any event, the plant should be so planned as to permit future expansion of these facilities at a minimum expense.

The question of what is the best plant operating pressure can be settled only through a careful study of all the conditions surrounding the production and marketing of both the oil and the gas. The most vital point is the relative value of the natural gasoline if left in the crude oil as compared with its value as a separate product. If this material has more value in the crude, higher final trap and gasoline plant operating pressures are indicated, and vice versa. Subject to this limitation, the higher the plant pressure the more economical the whole operation is likely to be, since raising the plant pressure obviously reduces the compressor horsepower required for returning the gas.

It is my opinion that gasoline plants operating in conjunction with gas injection will tend toward higher pressures than have been used, combined with stabilization of the crude to give it marketable specifications. In view of some recent work, I believe it is entirely practical to operate an absorption plant at pressures of at least 1200 lbs./sq. in.

Conclusions

Gas pressure maintenance or repressuring operations tend to improve the operating conditions of natural gasoline plants associated with them in the following ways:

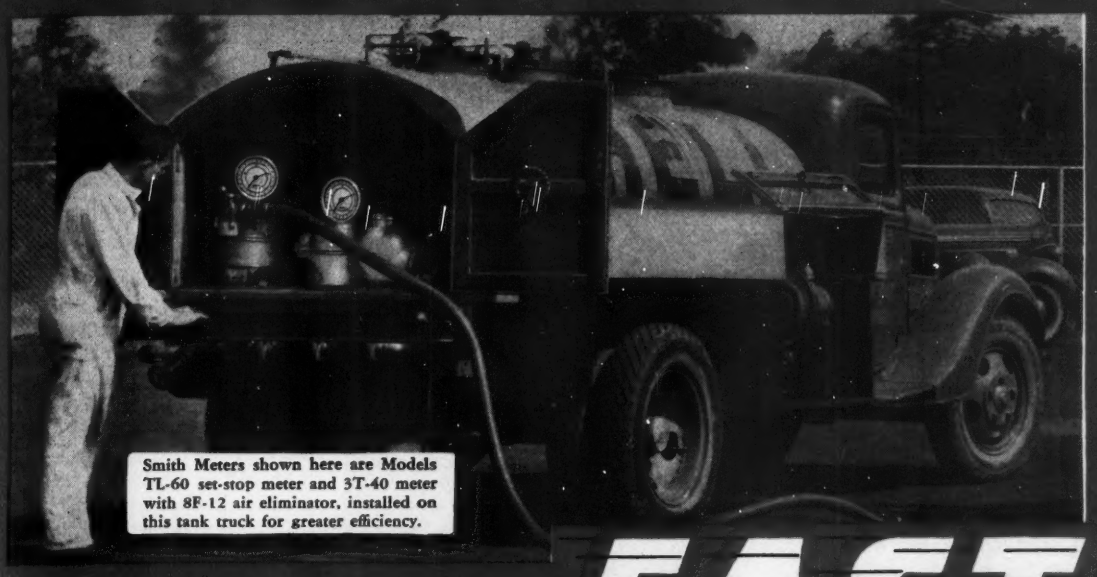
(a) By greatly increasing the average operating life.

(b) By stabilizing the rate of natural gasoline production.

(c) By preventing waste of dry gas which may be eventually sold.

In view of the results already accomplished, it is felt that this general subject deserves the earnest attention and support of everyone interested in natural gasoline production.

In closing, I want to express my thanks to A. K. Hegeman of Clark Bros. Co. and Jim Reed of Cooper-Bessemer for information on costs and supercompressibility, and to C. R. Williams of the Continental Oil Company, George Sowards of the Ohio Oil Company, and T. A. Huber of Humble Oil & Refining Company for data on actual operating results.



Smith Meters shown here are Models TL-60 set-stop meter and 3T-40 meter with 8F-12 air eliminator, installed on this tank truck for greater efficiency.

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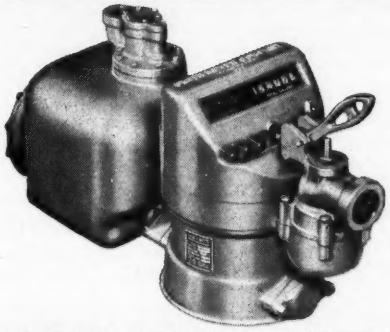
Here They Are!



Smith Meter Model 3T-40, equipped with horizontal counter, can also be furnished with vertical dial counter and set-stop valve for predetermined deliveries. Maximum capacity 50 g.p.m.

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Specific Gravity of Liquefied Petroleum Gases Determined by Hydrometer Method

By W. M. Schaufelberger,
Natural Gasoline Research Division,
Standard Oil Co. of Calif.

This paper covers the development of a rapid method for the determination of the specific gravity of liquefied petroleum gases by the use of a hydrometer at low temperatures and at atmospheric pressure.

In the past, specific gravity determinations on liquefied petroleum gas stocks have been run by a bomb weighing method such as described by the Natural Gasoline Association of America in the April 6, 1932, issue of National Petroleum News. This method necessitated the service of a laboratory man and required from thirty to sixty minutes' time.

A rapid method such as developed here is especially desirable when loading tank cars, since the I.C.C. regulations specify that the maximum filling volume be based upon a representative gravity of the contents of the car. A gravity determination must therefore be made simultaneously with the final adjustment of the level in the tank car and it is impractical to hold up the loading crew for a lengthy laboratory test.

Method

The apparatus is illustrated in Figure I and a detailed procedure is given at the end of this paper. The method is essentially the same as the standard A.S.T.M. gravity test by hydrometer. Samples must of course be cooled to a sufficiently low temperature to prevent weathering. Cooling is accomplished by passing the stock through a coil immersed in a propane bath in the case of butane stocks and in a CO_2 propane bath in the case of propane stocks. By substituting an unsilvered vacuum flask for the hydrometer jar, the temperature rise of the precooled stock is sufficiently retarded to permit accurate temperature and gravity readings.

Standardization

Standardization was effected by establishing low temperature specific gravity curves with hydrometers and extending these curves to the 60°F./60°F. specific gravity values determined by the bomb method. Figure II shows the curves for the six experimental stocks together with a plot of Dana, Jenkins, Burdick and Timm's data for propane, isobutane and normal butane. The low temperature determinations were made with two different hydrometers and with a chainomatic Westphal balance. The data obtained with these three instruments checked very closely. The 60°F./60°F specific gravities were checked by three experienced operators and by calculation from fractional analysis. Calculated and determined values are shown in Figure III, Sec. A.

W. M. Schaufelberger

The physical constants used in calculating the specific gravities from fractional analysis are shown in Figure III, Sec. B. This table gives the specific gravity values for pure propane, isobutane and normal butane published by (1) The California Natural Gasoline Association, (2) Dana, Jenkins, Burdick and Timm, and (3) Van der Vet. References to the original articles are given in the footnote to the table. It will be seen that the California Natural Gasoline Association values are nearly averages of the other two. Van der Vet has shown that propane and butane contract in volume upon mixing, and that this contraction effect may be expressed as a function of composition, Figure III, Sec. C. Applying this correction in the specific gravity computations, the California Natural Gasoline Association Values are found to be in best agreement with bomb gravity determinations.

Preparation of Conversion Tables

In order to prepare detailed conversion tables, the curves in Figure II were used to construct a large-scale cross-plot showing observed versus 60°F/-60°F. specific gravity curves at 1° F. intervals. From this cross-plot the "Specific Gravity-Temperature Correction Tables" attached to the procedure were prepared. The form of these tables is identical to the standard A.P.I. gravity-temperature correction tables used throughout the oil industry.

Accuracy

If the procedure is closely followed and the hydrometers and thermometers are properly calibrated, it is believed that specific gravity determinations will be accurate to one point in the third decimal place (±0.001).

Safety Practice

The test should receive the same care that is accorded gravity determinations on light gasoline stocks. That is, it should be conducted either in a well ventilated room or in the open and at a location remote from flames, electric heaters and sources of static sparks.

Application

This test has been used by the Natural Gasoline Department of the Standard Oil Company of California for several months with very satisfactory results. The time required for conducting a test is only ten to fifteen minutes, and the procedure is sufficiently convenient that it may be applied by the loading rack foreman. It therefore saves considerable time in loading tank cars.

Because of its simplicity, accuracy and practical value, the test is recommended for consideration by the Liquefied Petroleum Gas Committee of the California Natural Gasoline Association.

Procedure for determining the specific gravity of Liquefied Petroleum gases by means of a hydrometer.

APPARATUS

Hydrometers

1. The hydrometers shall conform to the following specifications: (a) Specific Gravity Scale 0.580 to 0.600 (60°F/60° F.); (b) Specific Gravity Scale 0.600 to 0.620 (60°F/60°F); Material: Glass suitable for use at temperatures as low as —70°F.

Scale Divisions: 0.001 sp. gr. Each fifth scale division shall be denoted by a line encircling the steam. Graduations shall be numbered at each multiple of 0.01 of specific gravity.

Accuracy: Better than 0.001 sp. gr.

Scale Length: 2" to 3". O. D. of Stem: 3/16"-¼".

Hydrometer Length: 6" to 8".

The material used in sealing the weighting substances should be capable of withstanding a temperature of —70° F. without cracking. Bottom tip of hydrometer should be cone shaped.

A standardized hydrometer should be kept on hand and new hydrometers

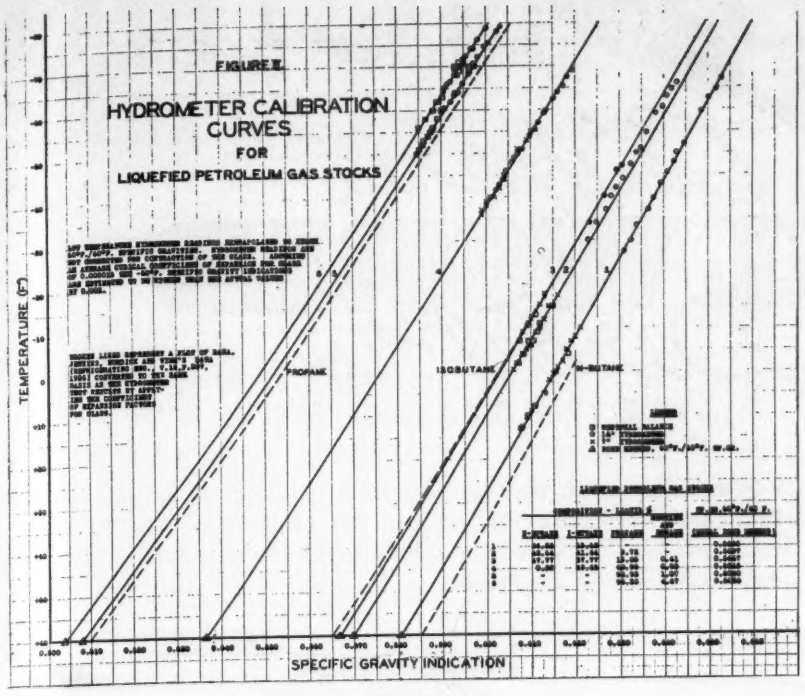

FIGURE III

SEC. A. COMPOSITION AND 60°F./60°F. SPECIFIC GRAVITIES OF BUTANE AND PROPANE STOCKS

	Composition (Liquid %)				Specific Gravity (60°F./60°F.)		
	1	2	3	4	5	6	7
	N-Butane	I-Butane	Propane	Methane & Ethane	Calculated *C.N.G.A.	**Corrected	Metal Bomb Method
1.	84.52	15.48	-	-	0.5809	0.5809	0.5805
2.	48.64	41.64	9.72	-	0.5684	0.5697	0.5697
3.	47.77	37.77	13.85	0.61	0.5650	0.5669	0.5667
4.	0.50	49.62	48.95	0.93	0.5357	0.5391	0.5365
5.	-	-	98.93	1.07	0.5078	0.5080	0.5080
6.	-	-	95.33	4.67	0.5039	0.5038	0.5038

*The C.N.G.A. constants were used in calculating the specific gravities in Column 5.
**The Van der Vet shrinkage factors (see Sec.C) were used for correcting the densities in Column 5 to the values given in Column 6.

SEC. B. SPECIFIC GRAVITIES OF PURE COMPONENTS

	C.N.G.A.	D.J.B.& T.	Van der Vet
N-Butane	0.584	0.5851	0.5832
Isobutane	0.564	0.5650	0.5636
Propane	0.509	0.5096	0.5079

C.N.G.A.Bulletin TS-311, "Tentative Standard Method for the Analysis of Natural Gasoline by Fractional Distillation," p.14 (1931).
Dana, Jenkins, Burdick & Tinn, Refrigerating Eng., V.12, p.387 (1926).
Van der Vet, Congres Mondial Du Petrole (Paris) B.49 S.2 (1937).

SEC. C. *VAN DER VET CONTRACTION TABLE FOR BUTANE-PROPANE MIXTURES
(Corrections to be Added to Densities *Calculated from Fractional Analysis)

Mol % C_3H_8	Correction	Mol % C_3H_8	Correction	Mol % C_3H_8	Correction	Mol % C_3H_8	Correction
5	0.0007	30	0.0032	55	0.0033	80	0.0018
10	0.0014	35	0.0034	60	0.0031	85	0.0014
15	0.0020	40	0.0035	65	0.0028	90	0.0009
20	0.0026	45	0.0036	70	0.0026	95	0.0005
25	0.0029	50	0.0035	75	0.0022	100	0.0000

*Applicable particularly to propane-normal butane mixtures.

should be checked against this standard before they are placed in service.

Thermometer

2. The thermometer used shall conform with specifications for A.S.T.M. D 97-34 "Low Cloud and Pour Test" except that the temperature range is to be reduced without changing the scale length.

Temperature Range: 0°F. to —75°F.
Scale Divisions: 1°F.
Scale Length: 2½" to 3½".
Immersion: 4½".

Cooling Bath

3. The cooling bath shall consist of a Pyrex glass vacuum flask, containing a copper coil and a suitable refrigerating liquid.

Vacuum Flask

(a) The Pyrex glass vacuum flask shall be at least 2½" I. D. by 11½" deep with wide mouth. (American Thermos Bottle Co. 1 qt. Pyrex Thermos Jar Cat. #8645.)

Copper Coil

(b) The copper coil shall consist of 20 ft. of 3/16" O.D. soft copper tubing wound on a hollow mandrel 2⅛" O.D. with adjacent turns touching. The lower end of the coil shall be brought up through the center of the mandrel before winding so that the finished coil will snugly fit the sides of the vacuum flask. This will give plenty of room in the center for introducing CO_2-snow. The top of this coil must be at least 1" below the top of the vacuum flask when assembled.

The ends of the copper coil shall not exceed more than a few inches beyond the mouth of the flask. The upstream end shall be connected directly to the sampling line of ¼" iron pipe. The downstream end shall be connected to a ⅛" needle valve provided with a connection not more than 2"-3" long.

Refrigerating Liquid

(c) The choice of refrigerating liquid depends upon the vapor pressure of the stock to be tested. For stocks with vapor pressures above 100# abs. at 100° F. a bath of CO_2-snow in propane shall be used. For less volatile stocks a propane bath may be used.

It is essential that the CO_2 be placed in the bath before adding the propane and that sufficient CO_2 be present at all times to produce a viscous mixture. The bath shall completely cover the copper cooling coil.

Sample Flask

4. The sample flask shall be an unsilvered Pyrex glass vacuum flask 2½" I.D. x 11½" deep with wide mouth (American Thermos Bottle Co. 1 qt. Pyrex Thermos Jar similar to Cat. #8645, but unsilvered).

Auxiliary Equipment

5. (See Figure I.)

ANNOUNCING

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TABLE I - SHEET 1

SPECIFIC GRAVITY-TEMPERATURE CORRECTION TABLE
LIQUEFIED PETROLEUM GASES

Obs. Temp. °F.	Hydrometer Indication 0.585	0.586	0.587	0.588	0.589	0.590	0.591	0.592	0.593	0.594	0.595	0.596	0.597	0.598	0.599	0.600	Obs Temp °F.
	Specific Gravity 60°F./60°F.																
-75														0.500	0.501	0.502	-75
-74														0.500	0.502	0.503	-74
-73												0.500	0.501	0.502	0.504	0.505	-73
-72												0.501	0.502	0.503	0.504	0.506	-72
-71											0.500	0.501	0.503	0.504	0.505	0.507	-71
-70										0.500	0.501	0.502	0.504	0.505	0.506	0.507	-70
-69										0.501	0.502	0.503	0.504	0.506	0.507	0.508	-69
-68									0.500	0.502	0.503	0.504	0.505	0.506	0.508	0.509	-68
-67									0.501	0.502	0.504	0.505	0.506	0.507	0.509	0.510	-67
-66								0.500	0.502	0.503	0.504	0.506	0.507	0.508	0.510	0.511	-66
-65							0.500	0.501	0.503	0.504	0.505	0.506	0.508	0.509	0.510	0.512	-65
-64							0.501	0.502	0.503	0.505	0.506	0.507	0.508	0.510	0.511	0.512	-64
-63						0.500	0.502	0.503	0.504	0.506	0.507	0.508	0.509	0.510	0.512	0.513	-63
-62						0.501	0.502	0.504	0.505	0.506	0.507	0.509	0.510	0.511	0.512	0.514	-62
-61					0.500	0.502	0.503	0.504	0.506	0.507	0.508	0.509	0.511	0.512	0.513	0.514	-61
-60	0.500	0.501	0.503	0.504	0.505	0.506	0.508	0.509	0.510	0.512	0.513	0.514	0.515	0.517	0.518	0.519	-60
-59	0.501	0.502	0.503	0.505	0.506	0.507	0.508	0.510	0.511	0.512	0.514	0.515	0.516	0.517	0.519	0.520	-59
-58	0.502	0.503	0.504	0.506	0.507	0.508	0.509	0.511	0.512	0.513	0.514	0.516	0.517	0.518	0.520	0.521	-58
-57	0.503	0.504	0.505	0.506	0.508	0.509	0.510	0.512	0.513	0.514	0.515	0.516	0.518	0.519	0.520	0.522	-57
-56	0.504	0.505	0.506	0.507	0.509	0.510	0.511	0.512	0.514	0.515	0.516	0.517	0.519	0.520	0.521	0.522	-56
-55	0.504	0.506	0.507	0.508	0.509	0.511	0.512	0.513	0.514	0.516	0.517	0.518	0.519	0.521	0.522	0.523	-55
-54	0.505	0.507	0.508	0.509	0.510	0.512	0.513	0.514	0.515	0.517	0.518	0.519	0.520	0.522	0.523	0.524	-54
-53	0.506	0.507	0.509	0.510	0.511	0.512	0.514	0.515	0.516	0.517	0.518	0.520	0.521	0.522	0.524	0.525	-53
-52	0.507	0.508	0.509	0.511	0.512	0.513	0.514	0.516	0.517	0.518	0.519	0.521	0.522	0.523	0.524	0.526	-52
-51	0.508	0.509	0.510	0.511	0.513	0.514	0.515	0.516	0.518	0.519	0.520	0.521	0.522	0.524	0.525	0.526	-51
-50	0.508	0.510	0.511	0.512	0.513	0.515	0.516	0.517	0.518	0.520	0.521	0.522	0.523	0.525	0.526	0.527	-50

The auxiliary equipment shall consist of

(a) A tightly fitting cork for the sample flask with holes bored as shown in Figure I to fit the thermometer, stirring rod and filling tube. Also, a 3/16" vent hole shall be provided.

(b) A thermometer (#2 above).

(c) A stirrer consisting of a 1/16" brass rod with a semi-circular paddle fastened to the lower end as shown. This stirrer should slide freely in the cork and the semi-circular portion should be provided with a 5/16" hole to slide on the filling tube.

(d) A filling tube of ¼" O.D. copper tubing reaching to the bottom of the flask.

(e) A semi-circular basket of brass wire screen to protect the hydrometer from breakage.

(f) An extra vacuum flask to hold a supply of CO_2-snow.

(g) Rubber tubing for connections.

(h) Supplies of CO_2 and propane.

Kit

6. This apparatus shall be assembled in a kit such as shown in Figure I.

PROCEDURE

Cleaning

7. The hydrometer, thermometer, vacuum flask and equipment with which the sample comes in contact must be thoroughly dried before running each test. **Accurate test results cannot be expected if any moisture adheres to the hydrometer.**

Sampling Connections

8. The sample shall be taken from an appropriate tank or line connection in a manner which will yield representative material. The sampling valve shall have a large opening to prevent vaporization of the material due to drop in pressure through the valve seat. For the same reason, the line connecting with the apparatus shall be short and made up of ¼" pipe or larger.

Precooling

9. The sampling line shall be purged before opening valve (1) which admits the sample to the cooling coil. A precooling sample of the liquid shall be drawn by opening the sampling valve (2). The sample flask shall be filled to within 1" of the stopper. This sample should remain in the flask for 1 to 2 minutes to precool the apparatus. It shall then be discarded and the test sample shall be drawn immediately.

Sampling

10. The test sample shall be drawn over a period of about one minute, bringing the level up to a point where the hydrometer floats freely. The thermometer shall be adjusted so that the immersion mark is even with the surface of the liquid.

Readings

11. The sample shall be stirred by moving the stirrer through the full depth of the liquid until the temperature becomes uniform. The temperature shall then be read to 1°F. and the gravity shall be read as quickly as possible

TABLE I - SHEET 2

SPECIFIC GRAVITY-TEMPERATURE CORRECTION TABLE
LIQUEFIED PETROLEUM GASES

Obs. Temp. °F.	Hydrometer Indication 0.601	0.602	0.603	0.604	0.605	0.606	0.607	0.608	0.609	0.610	Obs. Temp. °F.
	Specific Gravity 60°F./60°F.										
-75	0.509	0.510	0.511	0.512	0.514	0.515	0.516	0.518	0.519	0.520	-75
-74	0.509	0.511	0.512	0.513	0.514	0.516	0.517	0.518	0.520	0.521	-74
-73	0.510	0.511	0.513	0.514	0.515	0.517	0.518	0.519	0.520	0.522	-73
-72	0.511	0.512	0.514	0.515	0.516	0.518	0.519	0.520	0.521	0.523	-72
-71	0.512	0.513	0.514	0.516	0.517	0.518	0.520	0.521	0.522	0.523	-71
-70	0.513	0.514	0.515	0.516	0.518	0.519	0.520	0.522	0.523	0.524	-70
-69	0.513	0.515	0.516	0.517	0.518	0.520	0.521	0.522	0.524	0.525	-69
-68	0.514	0.515	0.517	0.518	0.519	0.521	0.522	0.523	0.524	0.526	-68
-67	0.515	0.516	0.516	0.519	0.520	0.521	0.523	0.524	0.525	0.526	-67
-66	0.516	0.517	0.518	0.520	0.521	0.522	0.524	0.525	0.526	0.527	-66
-65	0.516	0.518	0.519	0.520	0.522	0.523	0.524	0.525	0.527	0.528	-65
-64	0.517	0.519	0.520	0.521	0.522	0.524	0.525	0.526	0.528	0.529	-64
-63	0.518	0.519	0.521	0.522	0.523	0.524	0.526	0.527	0.528	0.530	-63
-62	0.519	0.520	0.521	0.523	0.524	0.525	0.526	0.528	0.529	0.530	-62
-61	0.520	0.521	0.522	0.523	0.525	0.526	0.527	0.528	0.530	0.531	-61
-60	0.520	0.522	0.523	0.524	0.526	0.527	0.528	0.529	0.531	0.532	-60
-59	0.521	0.522	0.523	0.525	0.526	0.527	0.529	0.530	0.531	0.532	-59
-58	0.522	0.523	0.524	0.526	0.527	0.528	0.529	0.531	0.532	0.533	-58
-57	0.523	0.524	0.525	0.526	0.526	0.529	0.530	0.532	0.533	0.534	-57
-56	0.524	0.525	0.526	0.527	0.529	0.530	0.531	0.532	0.534	0.535	-56
-55	0.524	0.526	0.527	0.528	0.529	0.531	0.532	0.533	0.534	0.536	-55
-54	0.525	0.526	0.526	0.529	0.530	0.532	0.533	0.534	0.536	0.536	-54
-53	0.526	0.527	0.528	0.530	0.531	0.532	0.534	0.536	0.536	0.537	-53
-52	0.527	0.528	0.529	0.530	0.532	0.533	0.534	0.535	0.537	0.538	-52
-51	0.527	0.529	0.530	0.531	0.532	0.534	0.535	0.536	0.538	0.539	-51
-50	0.528	0.530	0.531	0.532	0.533	0.534	0.536	0.537	0.538	0.540	-50

TABLE I - SHEET 2

SPECIFIC GRAVITY-TEMPERATURE CORRECTION TABLE
LIQUEFIED PETROLEUM GASES

Obs. Temp. °F.	Hydrometer Indication 0.611	0.612	0.613	0.614	0.615	0.616	0.617	0.618	0.619	0.620	Obs. Temp. °F.
	Specific Gravity 60°F./60°F.										
-75	0.522	0.523	0.524	0.526	0.527	0.528	0.529	0.531	0.532	0.533	-75
-74	0.522	0.524	0.525	0.526	0.528	0.529	0.530	0.531	0.533	0.534	-74
-73	0.523	0.524	0.526	0.527	0.528	0.530	0.531	0.532	0.534	0.535	-73
-72	0.524	0.525	0.526	0.528	0.529	0.530	0.531	0.532	0.534	0.536	-72
-71	0.525	0.526	0.527	0.529	0.530	0.531	0.532	0.534	0.535	0.536	-71
-70	0.526	0.527	0.528	0.529	0.531	0.532	0.533	0.534	0.536	0.537	-70
-69	0.526	0.528	0.529	0.530	0.531	0.533	0.534	0.535	0.536	0.538	-69
-68	0.527	0.528	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.539	-68
-67	0.528	0.529	0.530	0.532	0.533	0.534	0.536	0.537	0.538	0.539	-67
-66	0.529	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.539	0.540	-66
-65	0.529	0.530	0.532	0.533	0.534	0.536	0.537	0.538	0.539	0.541	-65
-64	0.530	0.531	0.533	0.534	0.535	0.536	0.538	0.539	0.540	0.541	-64
-63	0.531	0.532	0.533	0.535	0.536	0.537	0.538	0.540	0.541	0.542	-63
-62	0.532	0.533	0.534	0.535	0.537	0.538	0.539	0.540	0.542	0.543	-62
-61	0.532	0.534	0.535	0.536	0.537	0.539	0.540	0.541	0.542	0.544	-61
-60	0.533	0.534	0.536	0.537	0.538	0.540	0.541	0.542	0.543	0.544	-60
-59	0.534	0.535	0.536	0.538	0.539	0.540	0.541	0.542	0.544	0.545	-59
-58	0.534	0.536	0.537	0.538	0.540	0.541	0.542	0.543	0.544	0.546	-58
-57	0.535	0.536	0.539	0.539	0.540	0.542	0.543	0.544	0.545	0.546	-57
-56	0.536	0.537	0.539	0.540	0.541	0.542	0.544	0.545	0.546	0.547	-56
-55	0.537	0.538	0.539	0.541	0.542	0.543	0.544	0.546	0.547	0.548	-55
-54	0.538	0.539	0.540	0.542	0.543	0.544	0.545	0.546	0.548	0.549	-54
-53	0.538	0.540	0.541	0.542	0.543	0.545	0.546	0.547	0.548	0.550	-53
-52	0.539	0.540	0.542	0.543	0.544	0.545	0.547	0.548	0.549	0.550	-52
-51	0.540	0.541	0.542	0.544	0.545	0.546	0.547	0.549	0.550	0.551	-51
-50	0.541	0.542	0.543	0.544	0.546	0.547	0.548	0.549	0.551	0.552	-50

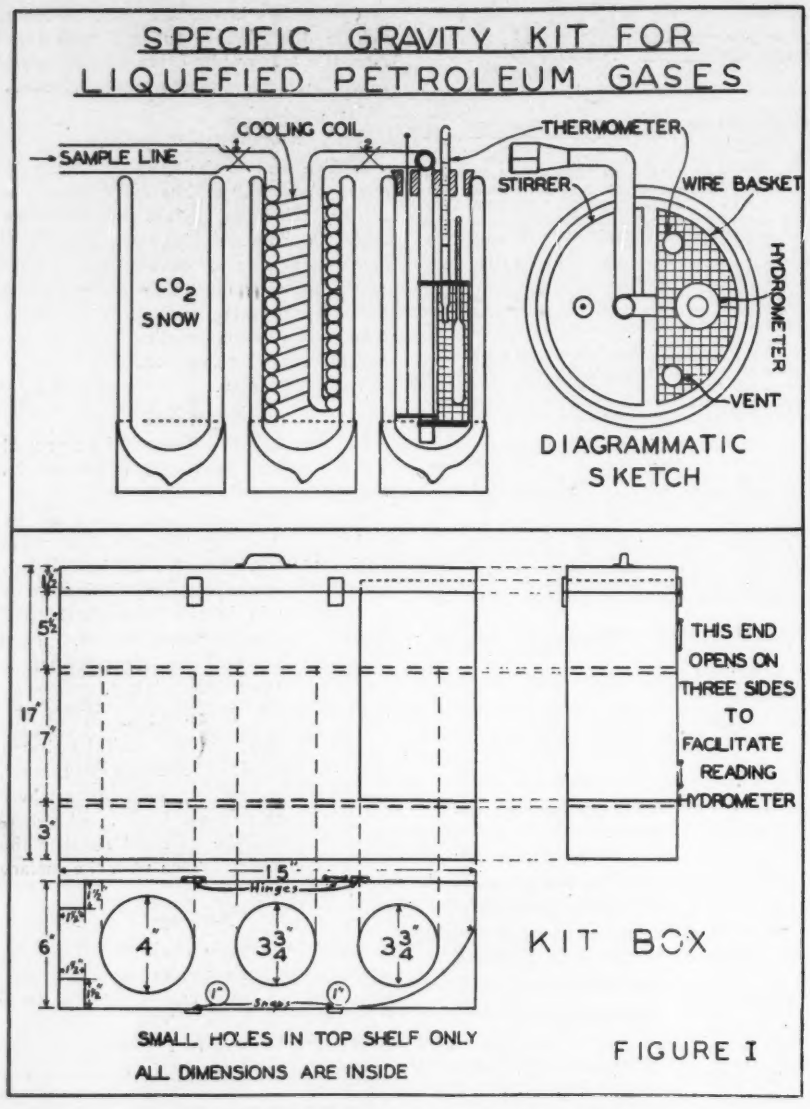


FIGURE I

to 0.001 sp. gr. The sample shall again be stirred and a second set of readings taken. Successive determinations shall be made until three identical 60°F./60° F. gravities are obtained.

Interpretation of Results

12. The specific gravity corrected to 60°F. shall be obtained from the attached tables. The corrected value will be found opposite the observed temperature in the column headed by the observed gravity.

Dubbs Cracking Unit For Michigan Refinery

B. J. Skinner, president of Mid-West Refineries, Inc., Alma, Michigan, has just signed a license agreement with Universal Oil Products Co.

Construction of a Dubbscracking unit in the Mid-West plant will begin shortly.

It will be a 2-coil selective unit, designed to crack 1000 bbls. a day of 24-26 topped crude from the Porter, Michigan field, and simultaneously to reform 190 to 200 bbls. a day of straight-run Michigan gasoline.

The unit is to be designed by Universal engineers and will be built by Frick-Reid Supply Corp. under Universal supervision.

Mid-West thus becomes the fifth Universal licensee in Michigan. The others are White Star Refining Company (Socony-Vacuum) at Detroit; Naph-Sol Refining Company, Muskegon; McClanahan Refineries, Inc., St. Louis, and Leonard Refineries, Inc., Alma.

For several years Mid-West has operated a skimming plant of 3000 bbls. a day crude capacity.

T. E. McFall and V. M. Skinner are vice-presidents of Mid-West, C. L. Fillmore is secretary-treasurer, and John Marshall is general refinery superintendent.

Standard Retires Williams

Henry H. Williams, long time oil man and employe of the Standard Oil Co. for 26 years was retired from active service November 1. Mr. Williams, when retired, was assistant production superintendent for northern California.

TABLE I - SHEET 4

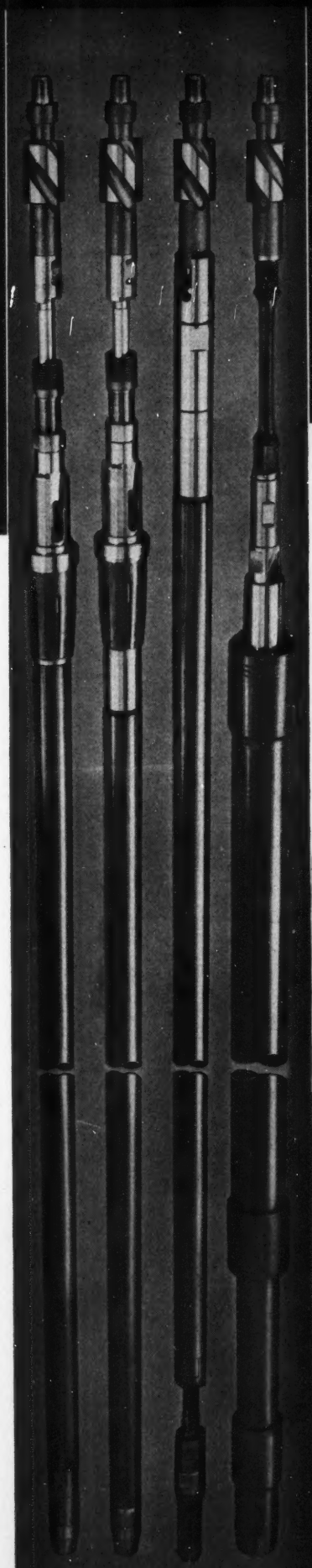
SPECIFIC GRAVITY-TEMPERATURE CORRECTION TABLE
LIQUEFIED PETROLEUM GASES

Obs. Temp. °F.	Hydrometer Indication 0.595	0.596	0.597	0.598	0.599	0.600	0.601	0.602	0.603	0.604	0.605	0.606	0.607	0.608	0.609	0.610	Obs. Temp. °F.
	Specific Gravity 60°F./60°F.																
-20	0.521	0.522	0.523	0.524	0.525	0.527	0.528	0.529	0.530	0.531	0.532	0.533	0.534	0.535	0.537	0.538	0.539	0.540	-20
-19	0.522	0.523	0.524	0.525	0.526	0.527	0.528	0.529	0.530	0.531	0.533	0.534	0.535	0.536	0.537	0.538	0.539	0.540	-19
-18	0.523	0.524	0.525	0.526	0.527	0.528	0.529	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.538	0.539	0.540	0.541	-18
-17	0.523	0.524	0.525	0.526	0.527	0.528	0.529	0.531	0.532	0.533	0.534	0.535	0.536	0.537	0.538	0.539	0.540	0.542	-17
-16	0.524	0.525	0.526	0.527	0.528	0.529	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.538	0.539	0.540	0.541	0.542	-16
-15	0.525	0.526	0.527	0.528	0.529	0.530	0.531	0.532	0.533	0.534	0.536	0.537	0.538	0.539	0.540	0.541	0.542	0.543	-15
-14	0.526	0.527	0.528	0.529	0.530	0.532	0.533	0.534	0.535	0.537	0.538	0.539	0.540	0.541	0.542	0.543	0.544	0.545	-14
-13	0.528	0.528	0.529	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.538	0.540	0.541	0.542	0.543	0.544	0.545	0.546	-13
-12	0.527	0.528	0.530	0.531	0.532	0.533	0.534	0.536	0.537	0.538	0.539	0.540	0.542	0.543	0.544	0.545	0.546	0.547	-12
-11	0.528	0.529	0.530	0.532	0.533	0.534	0.535	0.536	0.538	0.539	0.540	0.541	0.542	0.544	0.545	0.546	0.547	0.548	-11
-10	0.529	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.538	0.540	0.541	0.542	0.543	0.545	0.546	0.547	0.548	0.549	-10
-9	0.529	0.531	0.532	0.533	0.534	0.536	0.537	0.538	0.539	0.540	0.542	0.543	0.544	0.545	0.546	0.548	0.549	0.550	-9
-8	0.530	0.531	0.532	0.534	0.535	0.536	0.537	0.539	0.540	0.541	0.542	0.543	0.545	0.546	0.547	0.549	0.550	0.551	-8
-7	0.531	0.532	0.533	0.534	0.536	0.537	0.538	0.539	0.540	0.542	0.543	0.544	0.545	0.546	0.548	0.549	0.550	0.551	-7
-6	0.532	0.533	0.534	0.535	0.536	0.538	0.539	0.540	0.541	0.542	0.544	0.545	0.546	0.547	0.549	0.550	0.551	0.552	-6
-5	0.533	0.534	0.535	0.536	0.537	0.539	0.540	0.541	0.542	0.543	0.545	0.546	0.547	0.548	0.549	0.550	0.552	0.553	-5
-4	0.534	0.535	0.536	0.537	0.538	0.539	0.540	0.542	0.543	0.544	0.546	0.547	0.548	0.549	0.550	0.551	0.553	0.554	-4
-3	0.535	0.536	0.537	0.538	0.539	0.540	0.541	0.543	0.544	0.545	0.546	0.547	0.549	0.550	0.551	0.552	0.553	0.554	-3
-2	0.536	0.537	0.538	0.539	0.540	0.542	0.543	0.544	0.545	0.546	0.547	0.548	0.549	0.550	0.552	0.553	0.554	0.555	-2
-1	0.537	0.538	0.539	0.540	0.542	0.543	0.544	0.545	0.546	0.548	0.549	0.550	0.551	0.552	0.553	0.554	0.555	0.556	-1
0	0.538	0.539	0.540	0.541	0.543	0.544	0.545	0.546	0.548	0.549	0.550	0.551	0.552	0.553	0.554	0.555	0.556	0.557	0
1	0.539	0.540	0.541	0.543	0.544	0.545	0.546	0.547	0.549	0.550	0.551	0.552	0.553	0.554	0.555	0.556	0.557	0.558	1
2	0.540	0.541	0.542	0.544	0.545	0.546	0.547	0.548	0.550	0.551	0.552	0.553	0.554	0.555	0.556	0.557	0.558	0.559	2

TABLE I — SHEET 5
SPECIFIC GRAVITY—TEMPERATURE CORRECTION TABLE
LIQUEFIED PETROLEUM GASES

Obs. Temp. °F.	Hydrometer Indication 0.606	0.606	0.607	0.608	0.609	0.610	0.611	0.612	0.613	0.614	0.615	0.616	0.617	0.618	0.619	0.620	Obs. Temp. °F.
	Specific Gravity 60°F./60°F.																
-25	0.552	0.553	0.554	0.555	0.556	0.558	0.559	0.560	0.561	0.562	0.564	0.565	0.566	0.567	0.568	0.569	-25
-24	0.552	0.554	0.555	0.556	0.557	0.558	0.560	0.561	0.562	0.563	0.564	0.566	0.567	0.568	0.569	0.570	-24
-23	0.553	0.554	0.556	0.557	0.558	0.559	0.560	0.562	0.563	0.564	0.565	0.566	0.567	0.568	0.570	0.571	-23
-22	0.554	0.555	0.556	0.557	0.559	0.560	0.561	0.562	0.563	0.564	0.566	0.567	0.568	0.569	0.570	0.572	-22
-21	0.555	0.556	0.557	0.558	0.559	0.560	0.562	0.563	0.564	0.565	0.566	0.568	0.569	0.570	0.571	0.572	-21
-20	0.555	0.556	0.558	0.559	0.560	0.561	0.562	0.564	0.565	0.566	0.567	0.568	0.569	0.570	0.572	0.573	-20
-19	0.556	0.557	0.559	0.559	0.561	0.562	0.563	0.564	0.565	0.566	0.568	0.569	0.570	0.571	0.572	0.573	-19
-18	0.556	0.558	0.559	0.560	0.561	0.563	0.564	0.565	0.566	0.567	0.568	0.569	0.571	0.572	0.573	0.574	-18
-17	0.557	0.558	0.560	0.561	0.562	0.563	0.564	0.565	0.566	0.568	0.569	0.570	0.571	0.572	0.574	0.575	-17
-16	0.558	0.559	0.560	0.561	0.562	0.564	0.565	0.566	0.567	0.568	0.570	0.571	0.572	0.573	0.574	0.576	-16
-15	0.559	0.560	0.561	0.562	0.563	0.564	0.566	0.567	0.568	0.569	0.570	0.571	0.572	0.574	0.575	0.576	-15
-14	0.560	0.560	0.562	0.563	0.564	0.565	0.566	0.567	0.568	0.570	0.571	0.572	0.573	0.574	0.575	0.576	-14
-13	0.560	0.561	0.562	0.563	0.565	0.566	0.567	0.568	0.569	0.570	0.571	0.573	0.574	0.575	0.576	0.577	-13
-12	0.561	0.562	0.563	0.564	0.565	0.566	0.568	0.569	0.570	0.571	0.572	0.573	0.574	0.576	0.577	0.578	-12
-11	0.561	0.563	0.564	0.565	0.566	0.567	0.568	0.570	0.571	0.572	0.573	0.574	0.575	0.576	0.577	0.578	-11
-10	0.562	0.563	0.564	0.566	0.567	0.568	0.569	0.570	0.571	0.572	0.574	0.575	0.576	0.577	0.578	0.579	-10
- 9	0.563	0.564	0.565	0.566	0.567	0.569	0.570	0.571	0.572	0.573	0.574	0.575	0.576	0.578	0.579	0.580	- 9
- 8	0.564	0.565	0.566	0.567	0.568	0.569	0.570	0.572	0.573	0.574	0.575	0.576	0.577	0.578	0.579	0.580	- 8
- 7	0.564	0.566	0.566	0.568	0.569	0.570	0.571	0.572	0.573	0.574	0.576	0.577	0.578	0.579	0.580	0.581	- 7
- 6	0.565	0.566	0.567	0.568	0.569	0.570	0.572	0.573	0.574	0.575	0.576	0.577	0.578	0.579	0.581	0.582	- 6
- 5	0.566	0.567	0.568	0.569	0.570	0.571	0.572	0.573	0.574	0.576	0.577	0.578	0.579	0.580	0.581	0.582	- 5
- 4	0.566	0.567	0.568	0.570	0.571	0.572	0.573	0.574	0.575	0.576	0.578	0.579	0.580	0.581	0.582	0.583	- 4
- 3	0.567	0.568	0.569	0.570	0.571	0.572	0.574	0.575	0.576	0.577	0.578	0.579	0.580	0.581	0.582	0.584	- 3
- 2	0.568	0.569	0.570	0.571	0.572	0.573	0.574	0.575	0.576	0.578	0.579	0.580	0.581	0.582	0.583	0.584	- 2
- 1	0.569	0.569	0.571	0.572	0.573	0.574	0.575	0.576	0.577	0.578	0.580	0.581	0.582	0.583	0.584	0.585	- 1
0	0.569	0.570	0.571	0.572	0.574	0.575	0.576	0.577	0.578	0.579	0.580	0.581	0.582	0.584	0.585	0.586	0

FINE PARTS GIVE LONG LIFE TO AXELSON PUMPS



It's the little things that add up big. Twenty-five millionths of an inch is too little to be seen on a scale, but it's the limit in passing Axelson balls for size and roundness. Comparable accuracies are built into Axelson seats so that when the ball seats, it permits the maintenance of an almost perfect vacuum.

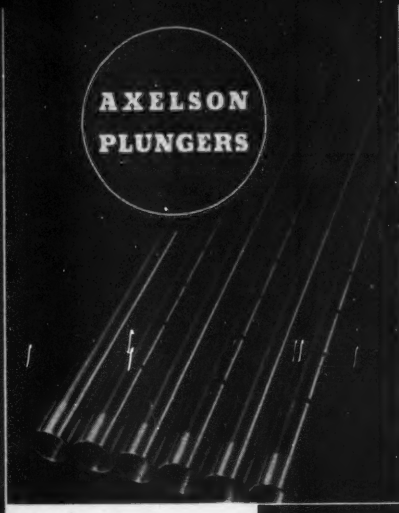
The faces of Axelson liners are so accurately squared and polished that when a dozen or more are stacked end on end they make an absolutely straight line and are air-tight at the joints.

Axelson plungers are as straight as a beam of light, and are polished to a mirror finish. This makes them work in the liner assembly with the least possible friction and loss of expensive power.

Add up all the Axelson accuracies in little things and you get the big advantages of Axelson practical performance by which you profit in low cost of production and minimum loss of time. Producers in every oil field in the world found that out long ago—to their profit.

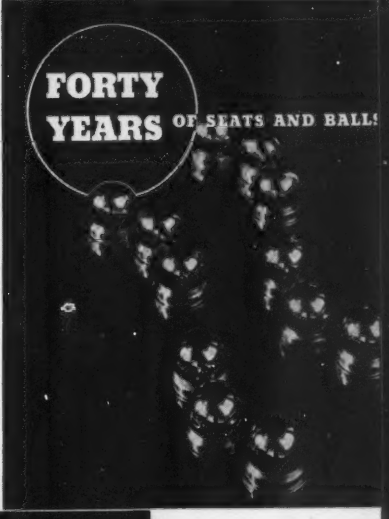
THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

AXELSON PLUNGERS



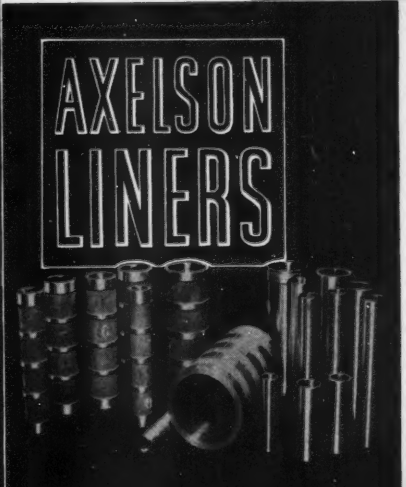
It takes a sixteen-page booklet to tell the mere outline of how Axelson plungers are made and why. It takes hundreds of thousands of dollars' worth of machines and equipment to make Axelson plungers the way they are. It has taken forty years of constant study and engineering progress to arrive at the refinements that are found in this single part of an Axelson pump, but it is these refinements and the refinements in all other Axelson pump parts that bring economy and dependability in the lifting of oil everywhere.

FORTY YEARS OF SEATS AND BALLS



Seats and balls are responsible for the heart action of deep well pumps. Twenty to sixty thousand times a day the ball in every cage of a pump comes down *smack* on the seat under a pressure that may be as high as 3000 pounds to the square inch. It takes real metal in both seat and ball to stand up. In forty years, Axelson has found not one metal and not one process with which to meet this condition, but has found many metals and many processes with which to meet any condition.

AXELSON LINERS



In the casting of liners, Axelson operates its own *controlled* foundry, in which one single piece of equipment is worth three or four times the value of an average trade foundry. It takes a thirty-six page booklet to tell how Axelson originated the first interchangeable liner and how Axelson liners are now made. There's a reason for everything that is done in the Axelson foundry, and all the reasons added together mean longer life and more economical production when you use Axelson pumps.

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Natural Gas in Storage, Repressuring and

Pressure Maintenance Viewed Analytically

By Stanley C. Herold
Los Angeles, Calif.

A well is a hole in the ground. It is nothing more, even though we may provide it with expensive equipment. It has no value unless it is in communication with some sort of an underground reservoir. When oil, gas, or water comes out of the reservoir, we call it production, and when any one of these fluids is put into the reservoir, we have no comprehensive name for it. Only in consideration of the purposes for this reverse process are the appropriate names available. These are storage, repressuring, and pressure maintenance. Instances of all three fluids being used in all three input processes can be cited. And to do this we need not go beyond southern California in space and ten years in time. Here the discussion must be confined to natural gas as the input fluid.

As a matter of fact there is no hard and fast line of demarcation between storage, repressuring, and pressure maintenance. This is only saying that the three processes are normally distinct, while there are cases which seem to be on border lines between them. Even so, the separation of these processes in our mental conceptions of them is essential in view of their individual purposes in economics and their individual requirements in the application of the principles of fluid mechanics.

Fluid Mechanics

The success or failure of reverse processes depends upon fluid mechanics, or perhaps more appropriately, reservoir mechanics. But there are two sets of mechanics which we encounter in sands. It is well, then, to know in any case which set it is that we have to deal with in any particular field. Perhaps with a brief description of these sets you will comprehend them.

The first set we have here in California. It also is found almost everywhere else in the world, except where we find the second set. The sands are found principally in Miocene and Pliocene formations. Outcrops of the same sands extend upward in the sky at high elevations. Rainwater enters at these outcrops; the pressure of water is great at depth along the flanks of any buried anticline, and these pressures often exceed 1500 pounds per square inch. If oil is produced from the anticline, the edgewater encroaches upon the pool, and if gas is pumped into such a pool, the edgewater recedes downward. Pumped-up wells can not attain a pressure greater than that of the water. Since the amount of water between the anticline and the outcrop is great, large quantities of gas can be pumped into the wells without the slightest noticeable increase in the pressure registered by a gauge at the well head.

The second set we find between the Rocky Mountains and the Atlantic Coast. This region obviously reaches from the west in North Texas to the east in the Province of Ontario, passing through Oklahoma, Kansas, Pennsylvania, New York, and the intervening states. The sands are found principally in Mississippian and Pennsylvanian formations. Outcrops of the same sands either do not exist or they stand at low elevations. In either case no rainwater enters the sands; the pressure of water is not great at depth along the flanks of any buried anticline, and these pressures are usually less than 1200 pounds per square inch. If oil is produced from the anticline, the edgewater does not encroach upon the pool, and if gas is pumped into such a pool, the edgewater does not recede downward. Pumped-up wells easily attain a pressure greater than that of the water. Every million cubic feet of gas pumped into the wells will register a noticeable increase in the pressure registered by a gauge at the well head. These facts should be easily recognized by petroleum engineers, but they are not. It makes a lot of difference whether we have the first set or the second set of mechanics at hand with a problem in storage, repressuring, or pressure maintenance.

You may ask what makes the difference between the sets. It is simply the resistance of gas bubbles dispersed throughout the oil and water in the porous sand. In the first case the water pressure is greater than the resistance; in the second case it is less. The question then is: When there is production does the water push the bubbles through the formation or do the bubbles hold the water back? And again, when gas is pumped into the wells can this gas push the water back, or do the bubbles protect the water? Perhaps some day petroleum engineers will recognize the strength of bubble resistance in their reservoirs. They have been told about it now for fifteen years.

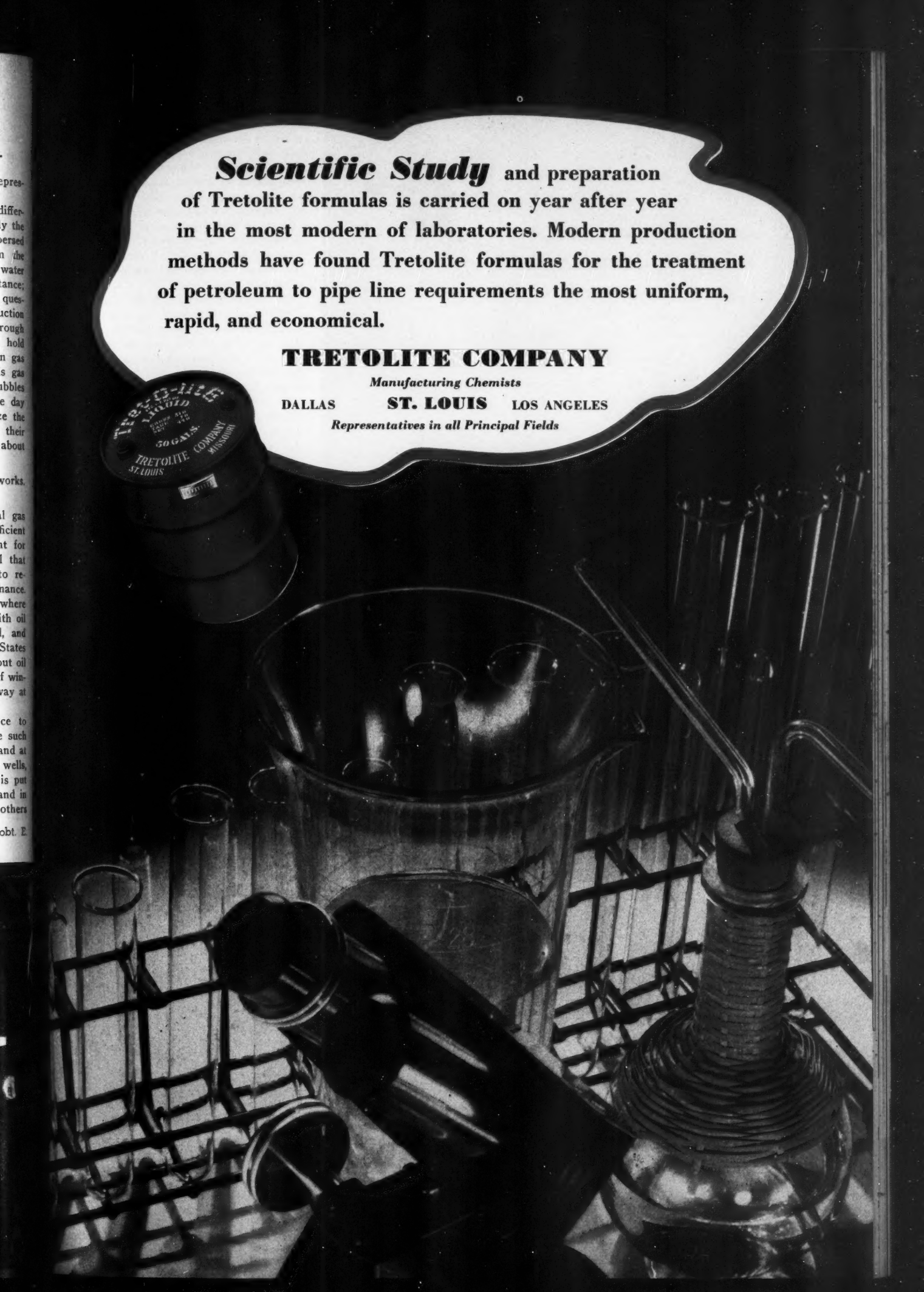
We shall see shortly how it works.

Gas Storage

Underground storage of natural gas in the usual instance is not of sufficient importance to us at this moment for full consideration. It is essential that we recognize its close relation to repressuring and pressure maintenance. There is storage in many States where the quantities of gas produced with oil are in excess of market demand, and also there is storage in other States where the production of gas without oil can not meet the heavy demands of winter without putting some of it away at a suitable place in summer.

There are cases with reference to excess gas coming with oil where such gas is put away in the same oil sand at some distance from the producing wells, there are others where such gas is put away in an upper or lower oil sand in the same field, and there are still others

Left to Right: W. M. Schaufelberger, D. B. Johns, Dr. Stanley C. Herold, Dr. Robt. E. Vivian, A. C. Rubel, T. Hume West.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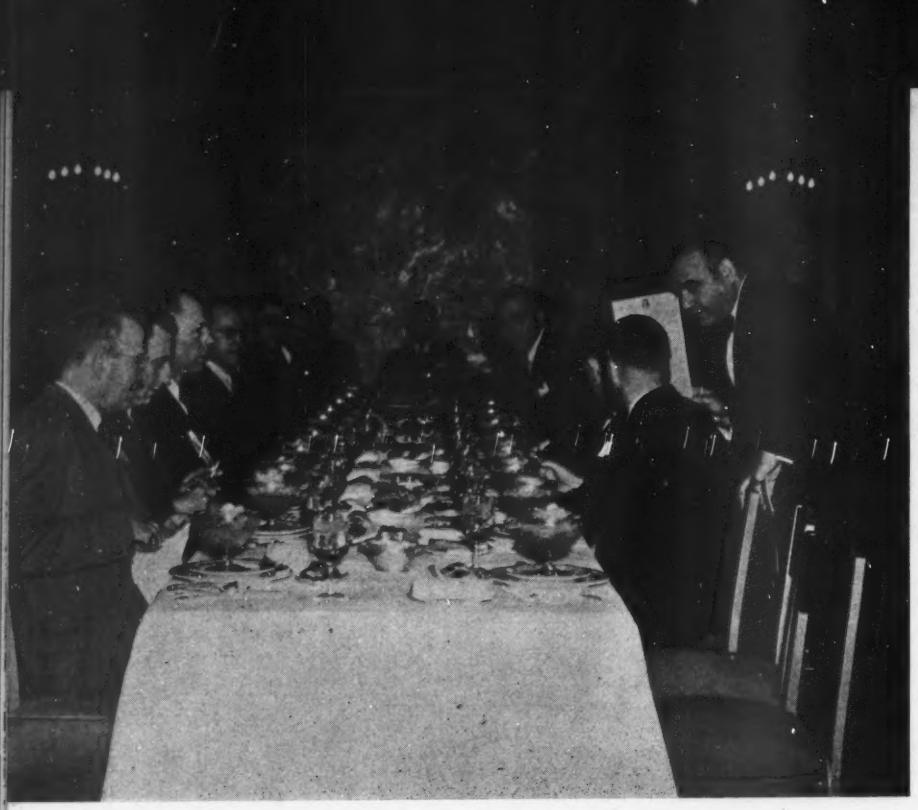


Speakers Luncheon

where the gas is piped to another distant field to be put into one of its sands. These are frequently regarded as, or claimed to be, instances of storage. That they are such is doubtful. Perhaps an operation should not be called storage unless the main interest lies in the return of the gas for later consumption. Certainly this is often not the purpose. Either there are laws prohibiting the blowing of this gas to the air, or there is in the mind of the operator an opportunity of rejuvenating the oil sand with gas. Whether the gas ever comes back to us is of no consideration.

Actual storage of excess gas in water sands is only in the experimental stage. There are hindrances to the success of this operation. The failure to produce water from the water sands, because of the lack of any economic purpose, lets the sand maintain its high pressure head without decline. It costs money to compress the gas sufficiently to push it into the sand, and unless there is some economic profit aside from the mere value of the gas it seems not the thing to do. The only obvious answer to this is to seek the higher sands with lower pressure heads. It is the decline of pressure in oil sands, and the increase in production rates of wells tapping them that encourage this so-called storage. But if it is the increase in production rates that is in mind, clearly the operation is one of repressuring, or of attempted repressuring, and not storage pure and simple.

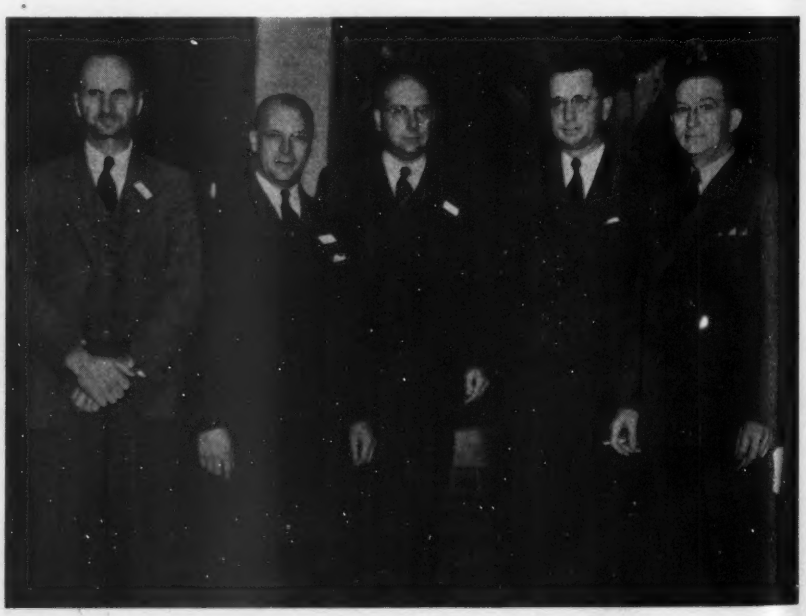
Repressuring

The idea of repressuring either a depleted or a partially depleted oil sand was fundamentally a result of accident. Surface rainwater got into some abandoned open holes near Bradford, Pennsylvania, and oil was observed to be coming out of wells lower down the hillside. That was forty or so years ago. Since then the operation of artificial flooding with water has been placed on a commercial basis. But if a drive of this sort works with water, why not with gas? So reasoned two men of Marietta, Ohio. By name these were Dunn and Lewis, now operating in Kansas and Oklahoma. In 1903 they proved the operation possible. Lacking gas in 1911, they tried air, and that worked, also. By 1916 these men had put their process on a commercial basis. Fields in which the rates of production in oil had reached low levels were rejuvenated. Wells were once more made profitable. It would be natural to suppose that gas has always been given preference over air. Generally it is available in sufficient quantity, it has the property of picking up petroleum vapors which can be recovered by treatment, and there is not the danger of handling an explosive mixture as there is with air.

The rejuvenation of old oil wells was clearly the issue; it was not the putting away of gas. And it is still thus. Some of the gas has always been able to by-pass oil in the reservoir, and so rise to the surface at the output wells. Although dry gas was put in, wet gas has come out. The by-passed oil has lost slightly in gravity, but this is not a serious matter.

This so-called Marietta process has been used generally with monetary profit. Certainly it is not as lucrative as the process of natural flow in gusher production, but it stands in fair competition with the late stages of settled production on gas-lift or pump. Original success in Ohio encouraged operators of other states to try it. Wells in various stages of final depletion have been treated accordingly in North Texas, Oklahoma, Kansas, Illinois, Kentucky, West Virginia, and elsewhere. There are a few instances of such operations on the Gulf Coast and in California.

Obviously these operations, being strictly of a rejuvenating nature, are confined to very old fields. The fields themselves are on their last legs, they have passed out of the limelight, and therefore we find little about them in



Left to Right: G. C. McLaren, H. R. Linhoff, P. S. Magruder, J. C. Burks, Wm. Moeller, Jr.

current literature. They seem to be of interest only to the technologists and operators who find themselves with a moribund group of wells on their hands. We face here an anomalous situation: While technologists concerned with water flooding in Pennsylvania and New York are writing profusely concerning the efficiency of their well-spacing patterns and field operations, other technologists do not concern themselves with like problems in gas flooding. They have jumped to the more spectacular features of pumping gas into new fields which have not had time to reach anywhere near a depletion.

Of course, well-spacing patterns and methods of operation are as important with gas as with water.

In the two classes of reservoirs previously mentioned oil wells go to pot differently. Our California wells, for example, go to water; first those the farthest down the flank of the structure, then the next, and so on, up toward the crest. Going to water is often indicated by a gradual increase in the cut for the oil; sometimes it is registered by noting oil today and all water tomorrow. On the other hand, wells in Oklahoma simply pass out. No water makes its appearance. Encroachment and non-encroachment should mean something regarding the bubble resistance within the reservoir.

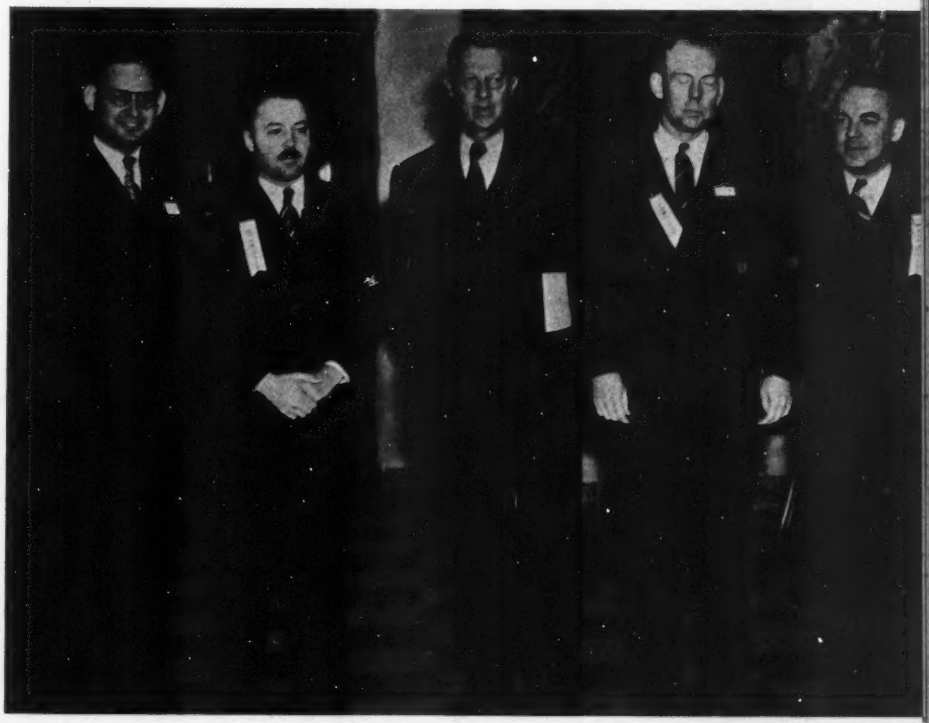
According to the first set of fluid mechanics, wherein encroachment is normal, any gas pumped into a well will gradually shift its position to the top of the structure. Any production from any well in the field will aid this shifting. We know how the gas moves. It is quiet in a large bubble for a few days, accumulating pressure with continued incoming gas, then it shoots loose in a body, expanding slightly as it moves, to a place not far from its first position. Again and again this happens, until it comes to final rest at its highest position.

Final rest? Not if there are producing wells at the crest. Those wells become flooded out with gas. Their gas-oil ratios mount to the tens of thousands of cubic feet per barrel of oil. They are therefore closed-in for the stated purpose of conserving gas and of complying with gas laws. Operators seek and get praise for virtuous performance.

But this gas, now retained at the crest, occupies space. Oil not only fails to come up the structure to be produced there, but it is in fact displaced down the structure to give way to the gas. In turn, the edgewater either is displaced downward, or it is detained in its encroachment, according to the amount of oil being produced on the flanks. Wells on the periphery are kept in oil, whereas they were due to go to water. There is no harm in this, provided the same operator owns crest, flank, and edge wells.

Now we have a contrasting situation in accordance with the second set of fluid mechanics, wherein non-encroachment is normal. Bubble resistance is sufficient to hold pumped-in gas and confine it to the immediate vicinity of the well. It can not shoot to the higher parts of the structure. The area of confinement is circular about the well, and the radius is dependent upon the

Left to Right: Lyman F. Scheel, Dr. Robt. E. Vivian, P. S. Magruder, T. Hume West, Wm. Moeller, Jr., Henry N. Wade.



Lef to Right: D. B. Johns, W. C. Dayhuff, Dr. Stanley C. Herold, C. D. Gard, George Christen.

porosity and thickness of the sand, the amount of gas pumped in, and the pressure to which it is subjected. The radius increases with the continued input. In turn this pocket of compressed gas pushes oil ahead of it in all directions. In fact bubbles of original gas within the oil are made smaller. We can say there is a ring of compressed oil surrounding the circle of gas. This ring itself has an areal width which increases as more gas is put in. Any well beyond this ring can not disturb this situation.

Let us suppose, however, that enough gas has been put in to cause the area of the compressed oil ring to overtake another well, and let us suppose this second well is opened. What happens? The second well at once becomes an output well for oil, and this output will continue either as long as there is an input of gas at the first well, or as long as there is oil ahead of the gas, between the wells. We know something about the area being subjected to this sweeping-out process. It is elliptical. Like all good elliptical figures it has two foci; one at the input well, and the other at the output well. If desired, the area of the ellipse can be determined in the field by the reading of a pressure gauge and the measurement of the distance between the two wells. As yet no one has desired this information.

This is the process of repressuring in two types of reservoirs. Where wells turn from oil wells to water wells, there is little encroachment for the repressuring of nearly depleted fields. But where oil wells just fizzle out to nothing, there it has been thought that a good shot of gas will revive them. For many years, then, these respective attitudes toward dying and dead wells have been held by practical operators without any knowledge or consideration of technology. Today, in terms of technology, we know they were correct, and we know why they were correct. And the end of the story of repressuring is not yet.

Pressure Maintenance

The successes of repressuring old reservoirs in the Mid-Continent and Eastern fields encouraged the consideration of pushing gas into new reservoirs. Profitable artificial gas-lift operations were contributory factors. Why wait, so it was reasoned, until a field reached a production hovering around an economic limit? We must give it a trial. In order to talk about it, let us call it pressure maintenance. A newly discovered pool has its highest pressure; our task is to take charge of that field as soon as possible and prevent, in so far as we can, any decline in that pressure.

A few years have passed now, since the original thought sprang up. There have been trials dating from 1926, and some of them are still in operation, since they appear to be successful. In California, on the Gulf Coast, and in the Mid-Continent regions we have noted this work. Some of the best known, having been described in current literature, are the following:

1) Seal Beach, California, 1926, pressures 1800 pounds per square inch. 2) Dominguez, California, 1926, pressures 1200 pounds per square inch. 3) Cook Ranch, Texas, 1927, pressures 60 pounds per square inch. 4) Sugarland, Texas, 1928, pressures 1350 pounds per square inch. 5) South Burbank, Oklahoma, 1935, pressures 900 pounds per square inch. 6) Sulphur, Louisiana, 1937, pressures 2000 pounds per square inch. 7) Cayuga, Texas, 1937, pressures 1800 pounds per square inch. 8) Naval Reserve, South Burbank, Oklahoma, 1937, pressures 400-700 pounds per square inch. 9) Tepetate, Louisiana, 1937, pressures 4500 pounds per square inch. 10) Sundance, Wyoming, 1938, pressures 860 pounds per square inch.

The higher pressures appear in the California and the Gulf Coast regions, and the lower ones in the Mid-Continent region. This conforms with the idea that the edgewater pushes the oil in the former and that it does not do so in the latter. In this connection it is of interest to recall once more the facts as to the manner in which wells peter out in these two areas. Now we see that in virtue of a maintenance of high pressure, even if it is a declined pressure, in California and on the Gulf Coast the putting in of gas in these areas is always more of the nature of pressure maintenance than of repressuring.

Here are facts that are not noted in our literature about these pressure maintenance operations: In California and on the Gulf Coast, all input wells push gas against the same closed-in reservoir pressure. The only difference possible is that pressure registered during actual pumping; obviously the faster the pump is run the greater is the pressure on the gauge. It is by shutting the pump down that the equal pressures are shown. In contrast to this is the fact that in the Mid-Continent region every well will register its own closed-in pressure. Only by chance will any two of them have the same amount.

That the foregoing situations are true is clear in view of what has been said before, namely, that gas can shoot up structure where bubble resistance is lower than the pressure of edgewater and that it is confined about the well where this resistance is higher than the pressure of edgewater.

The only reference to different pressures at wells in the same field is to be found in connection with the operations at the Naval Reserve Pool, South Burbank. There it is of record that the pressures vary between 400 and 700 pounds per square inch. One would naturally suppose that a petroleum engineer would have his curiosity aroused by such a variation in the same reservoir. Evidently the facts, if noted at all, go without questioning.

It is not necessary to repeat for pressure maintenance that which has been said here about the different reservoir conditions under the title of repressuring. The situations, of course, affect both operations in the same way from the point of view of fluid mechanics.

In some respects oil wells should be handled in the way we treat human beings and other animals. When one is dying a good shot of oxygen will prolong life. But when one is healthy and strong, why give the shot? From the point of view of economics there is a great difference between repressuring and pressure maintenance.

Current reasons for advocating pressure maintenance in new reservoirs include the following items:

True—(1) The greater the reservoir pressure the faster the rate of production from given wells. (2) Gas lift is an efficacious way of raising oil to the surface. (3) We prevent water encroachment in California and on the Gulf Coast.

False—(1) We increase the ultimate production from the reservoir. (2) We prevent water encroachment in the Mid-Continent region.

Useless—(1) We conserve reservoir energy.

Time will not permit here a complete discussion of the gas-lift, the ultimate production, and the conservation of energy. Let them abide with the classification just ascribed to them.

Conclusion

As a conclusion to this paper you are handed a problem. Your answer is to be Yes or No.

Imagine, if you will, that you, individually or as the manager of an oil company, have just acquired holdings in a newly discovered field which promises to be highly prolific. The oil is of good quality and there is plenty of gas. Along comes a man with the following story:

"My name is Stanley Herold. I graduated from Stanford University in 1909 from the Department of Geology. After dabbling around a bit I found myself in oil. That was in January, 1913. Since then I have remained in oil; thus I have had a long experience.

"When I was in college, I couldn't handle engineering mathematics; that is why I took geology. I didn't study physics. It wasn't required,

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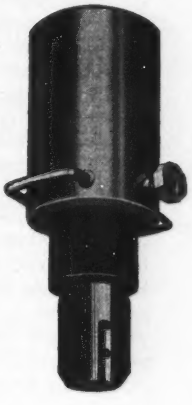

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and besides, it had theoretical mechanics in it. This required mathematics.

"I understand you have a new field. I want to help you in your development and operations. I propose pressure maintenance with excess gas after the natural gasoline has been taken out of it. You know that is the newest thing in production.

"I don't know anything about reservoir mechanics. It is purely a theoretical subject, anyway. I don't know whether the gas will stay near the input wells or slide up the structure. If it stays near the wells, I don't know what shape of an area it will cover, and I don't know any way of measuring that area so as to avoid the gas with future wells. If it slides up the structure, all we have to do is to shut down the crest wells. If it does so, I don't know what shape of an area it will cover, and I don't know any way of measuring that area. I'll watch the wells just down the flank from the crest and shut them in, as soon as they show an abnormal ratio.

"I'll prevent water encroachment upon your pool. I know it can be done for we kept the water back in Oklahoma where I used to work. If I keep your neighbors' wells in oil, and prevent them from going to water, you won't mind. Of course, if they went to water I know you would get that oil which I propose to give them, but you won't ever know that. Your records in the end will show only what you did get, and not what you might have gotten.

"All this I will do in the name of energy I have done a lot with that word in the past. It has economic appeal. Frankly I don't know what it has to do with production. I just talk about it. Perhaps it is related to gas. It is often best to use the word in connection with conservation. We all understand conservation of natural resources, so why not speak of the conservation of energy? No one will ask what that stuff looks like, but they smile knowingly and say, as you do, 'Why, yes, of course.'

"I'll mix things up generally for you in your reservoir; there will be gas some places and there will be oil other places. But I'll write reports telling how production rates are maintained or increased, and how the ultimate production is made greater. You will handle the simple little job of getting by with proration.

"To do this work I must have a salary of 1,000 dollars per month at the head of a department with 5 technical assistants for the field at 250 to 500 dollars per month and, of course, we shall need stenographic help and office equipment in general. An appropriation of 100,000 dollars will give us a start in the field.

"Wells drilled into gas pockets, and wells closed because they are flooded with gas will not be handled on my books. Your production treasurer can handle them, and as to those neighbors kept in oil, their accountants are fully competent to handle that subject.

"In consideration of my twenty-five years of practical experience with oil wells I have come to you.

"May I have the job?"

Unibolt Manufacturer Pacific Coast Visitor

Left, C. W. Thornhill, of Thornhill-Craver Co., Inc., Houston, manufacturers of "Unibolt" one bolt couplings. With him is L. E. Peck, California representative of the company. Mr. Thornhill is renewing old oil industry acquaintances on the Pacific Coast.

State Oil Safety Board To Include More Independents

After a year's experience that has definitely demonstrated the success of the principles maintained, the California Petroleum Safety Board is now expanding its services to include a greater number of independent oil companies in its membership.

The Safety Board, an outgrowth of an Oil Producers Agency Committee, but now a separate corporation with no agency nor other association affiliations, has been carrying on the first and only group safety program in the oil industry for the past year.

Details of group safety administration, of procedure, and of operation have been worked out by A. J. Martinson, safety director of the board, with these member companies, the result being that the board is now able to offer a proved and economical method of safety training to any and all companies who wish to avail themselves of the opportunity.

California Crude Oil Production

Two Weeks Ended November 12, 1938

Field	November Daily Quota	Average Daily Production	Excess
San Joaquin Valley			
Belridge—North	14,690	12,799	*1,891
Belridge—South	1,885	1,058	*827
Buena Vista	17,005	17,991	986
Canal	3,585	3,412	*173
Coalinga-East(Eocene)	1,740	1,862	122
Coalinga—East-West	15,917	6,483	*9,434
Coffee Canyon	2,930	3,019	89
Edison	2,455	2,462	7
Elk Hills	7,780	10,062	2,282
Fruitvale	7,145	8,890	1,745
Greeley	2,945	3,080	135
Kern Front	7,905	7,324	*581
Kern River	5,545	2,745	*2,800
Kettleman No. Dome	59,590	62,868	3,278
Lost Hills	4,270	3,310	*960
McKittrick	3,905	3,228	*677
Midway	42,621	32,518	*10,103
Mount Poso	13,909	14,789	880
Mountain View	8,625	9,848	1,223
Rio Bravo	5,340	8,495	3,155
Round Mountain	9,425	9,881	456
Ten Section	8,815	8,475	*340
Wasco	370	532	162
Other Fields	2,150	2,346	196
TOTAL	250,547	237,477	*13,070
Coastal Counties			
Elwood	4,895	5,203	308
Rincon	2,960	4,439	1,479
Santa Maria	5,930	3,208	*2,722
Gato Ridge	2,410	5,673	3,263
Santa Maria Valley	19,390	12,262	*7,128
Santa Paula-Newhall	5,160	5,924	764
Ventura Avenue	31,590	34,285	2,695
Other Fields	5,850	5,717	*133
TOTAL	78,185	76,711	*1,474
Los Angeles Basin			
Alamitos-Seal Beach	7,535	7,911	376
Brea-Olinda	8,355	5,604	*2,751
Coyote—East	2,625	3,009	384
Coyote—West	7,950	9,510	1,560
Domingues	19,910	26,655	6,745
El Segundo	4,455	6,217	1,762
Huntington Beach—New and Old	26,050	31,480	5,430
Inglewood	13,325	13,442	117
Long Beach	43,150	53,750	10,600
Montebello	6,220	6,122	*98
Montebello-West End	4,175	9,147	4,972
Playa del Rey	5,145	5,590	445
Richfield	7,705	8,198	493
Rosecrans-Athens	8,635	14,162	5,527
Santa Fe Springs	28,480	30,562	2,082
Torrance	15,493	19,467	3,974
Wilmington	69,765	95,377	25,612
Other Fields	2,640	2,950	310
TOTAL	281,613	349,153	67,540
STATE TOTAL	610,345	663,341	52,996

*—Shortage.

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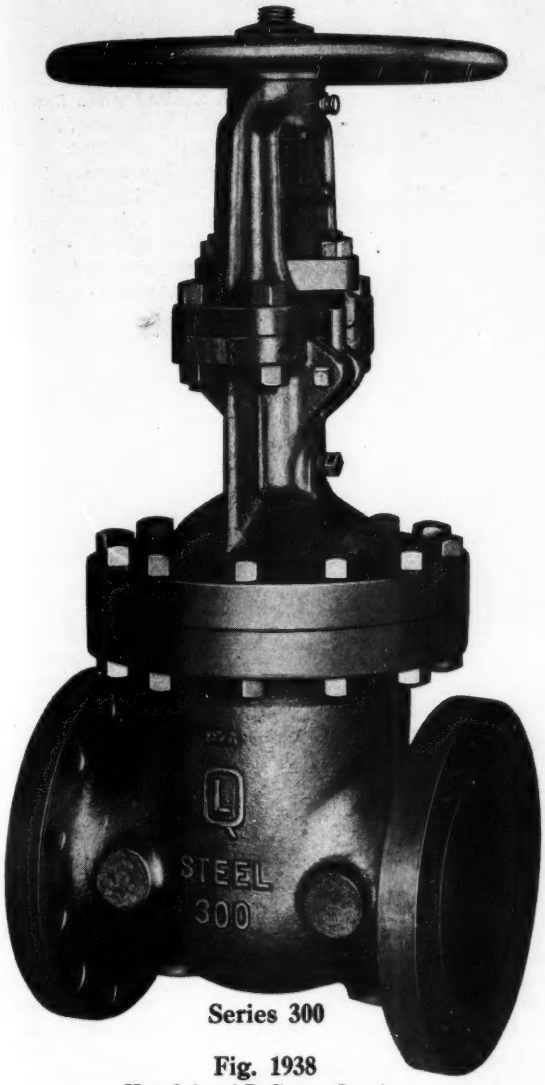

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Fig. 1498
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A New Absorptive Capacity Test for Absorption Oils

By D. B. Johns,
Natural Gasoline Research Div.,
Standard Oil Co. of Calif.

In the design and operation of plants for the extraction of gasoline from natural gas by the oil absorption process, the quantity and the quality of the oil circulated are factors of major importance. The purpose of this paper is to discuss the quality of absorption oil as reflected by absorptive capacity, and to present a new and simple test procedure for determining this property.

Kremser brought out in his paper, "Theoretical Analysis the Key to Absorption Plant Design," presented before the California Natural Gasoline Association in February, 1930, that absorption is dependent fundamentally upon the number of mols of oil circulated rather than upon the number of gallons. Gallons of oil may be converted to mols of oil by multiplying by the density to convert to a weight basis, and dividing by the average molecular weight of the oil. This is the D/M molal concentration factor used in Kremser's absorption factor equation.

$$\text{Absorption Factor} = A = 3.156\left(\frac{D}{M}\right)\frac{GP}{p},$$

wherein D = Specific gravity of absorption oil,
M = Molecular weight of absorption oil,
G = Oil rate (gallons per 1000 std. cu. ft. of gas),
and p = Vapor pressure of gasoline fraction in #/sq. in. abs. at absorber temperature.

The D/M factor has become recognized as an index of oil characteristics. In practice, it is desirable to keep this factor high by using the lowest boiling range oil consistent with permissible vaporization losses in the absorption and stripping systems. On a gravity basis this means the use of oils with a high A.P.I. gravity. Kremser's pointed out that a one-degree increase in the A.P.I. gravity will in general lower the molecular weight of an oil sufficiently to improve the absorption factor by approximately 2%. In terms of plant operation, this means that either the oil circulated may be cut by 2%, or advantage may be taken of the available increase in plant capacity.

The usual method of determining the molecular weight (M) of an absorption oil is the benzene freezing-point depression test which is described in the California Natural Gasoline Association

D. B. Johns

Bulletin TS-343, "Tentative Procedure for Testing Lean Absorption Oil." In this procedure, small amounts of the absorption oil are dissolved in benzene and the molecular weight is obtained from a measurement of the freezing-point depression. This method is credited with establishing reasonably true average molecular weights and therefore provides a means of determining the actual molal concentration or (D/M) ratio. However, the test requires extremely careful technique to obtain satisfactory results, the time requirement is excessive, and in general the method is unsuitable for determining the actual absorptive capacity of an oil.

This paper presents a quick and simple method of actually determining the relative absorptive capacity of an oil based on its ability to absorb butane gas. Data obtained by this method indicate that the absorptive capacity of an oil is not dependent solely upon the molal concentration factor (D/M), but involves an additional factor which is probably dependent upon the nature of the hydrocarbons of which the oil is composed.

New Absorptive Capacity Test

A diagrammatic sketch and a photograph of the apparatus for conducting the butane absorptive capacity test are shown in Figures 1 and 2. Figures 4 and 5 show optional absorption tube designs. The detailed testing procedure and the derivation of formulae for calculating absorptive capacity values are presented in the Appendix.

Describing the test briefly, a cross-cut of a liquid isobutane-normal butane stock is vaporized, cooled to 80°F., passed through a small glass flow rate indicator, saturated with water, scrubbed to remove entrained moisture, and finally passed through a measured quantity of absorption oil maintained at 80°F. until equilibrium is attained and the oil will absorb no more butane. The quantity of butane absorbed may be measured either by volume or weight increase.

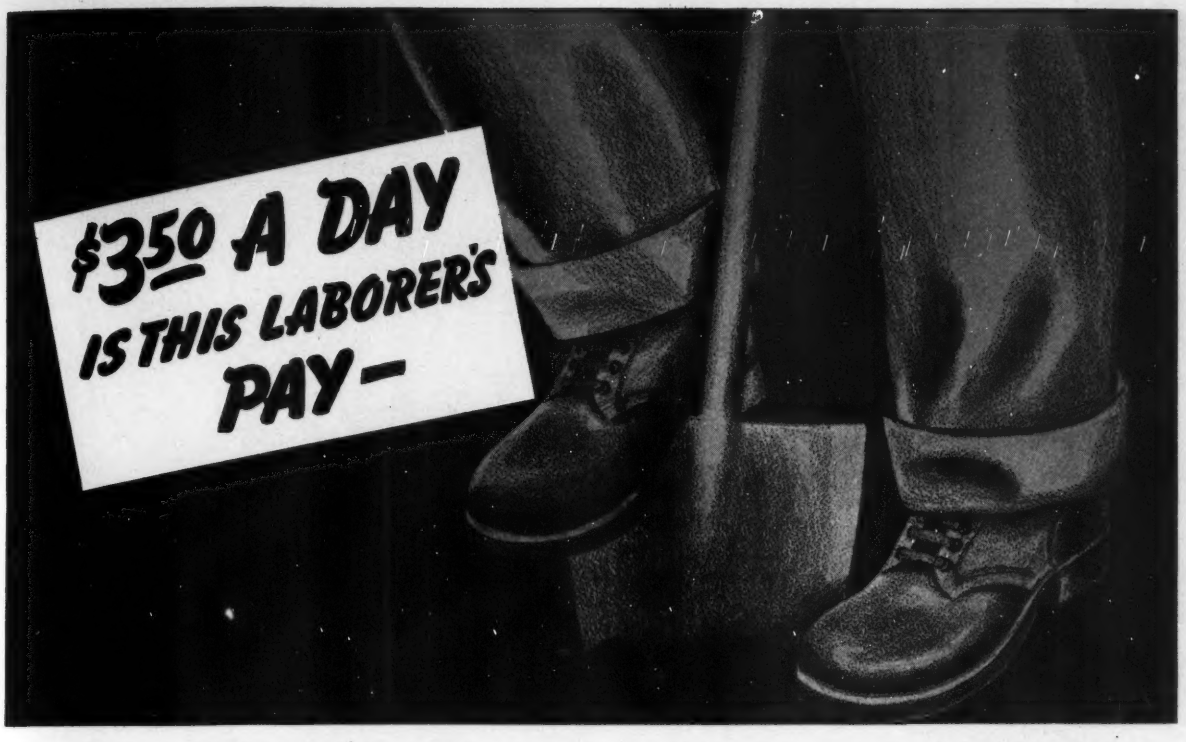
These weight or volume pick-up values, while indicative of absorptive capacity, cannot be applied directly in computations involving other conditions of absorption. However, by employing equilibrium relations, we may compute D/Me values, where Me is the apparent molecular weight. It is recognized that in the plant process, hydrocarbon fractions other than butanes are also being absorbed and that conditions of absorption depart from those of the test. However, it is believed that application of determined D/Me values, established for a key component, such as butane, under constant test conditions should be representative of the relative capacities of different oils under conditions other than those defined by the test.

The method is simple in principle, and it is possible with a dual apparatus, such as that shown in Figure 2, to conduct duplicate tests in less than two hours' time. The equipment shown in Figure 2 has been in satisfactory service for about two years.

In connection with the development of the new index of absorptive capacity, tests were run on many oils, including special cuts and both new and used oils furnished by several companies.

Gravimetric vs. Volumetric Procedure

In most cases, independent determinations were made by both weight pick-up and volume pick-up methods. The volumetric test is by far the more convenient to conduct, but it involves an additional factor resulting from the shrinkage in volume which occurs when two different hydrocarbon fractions are mixed. This shrinkage factor is the value "S" in the formula for computing test results given in Figure 3. The amount of shrinkage was found by test to be equivalent to 5% of the volume of dissolved butanes for a specific case. This value was applied generally to volumetric test results. Reasonable agreement of these data with corresponding gravimetric results indicates that this



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Six of the Eight splendid paper ted

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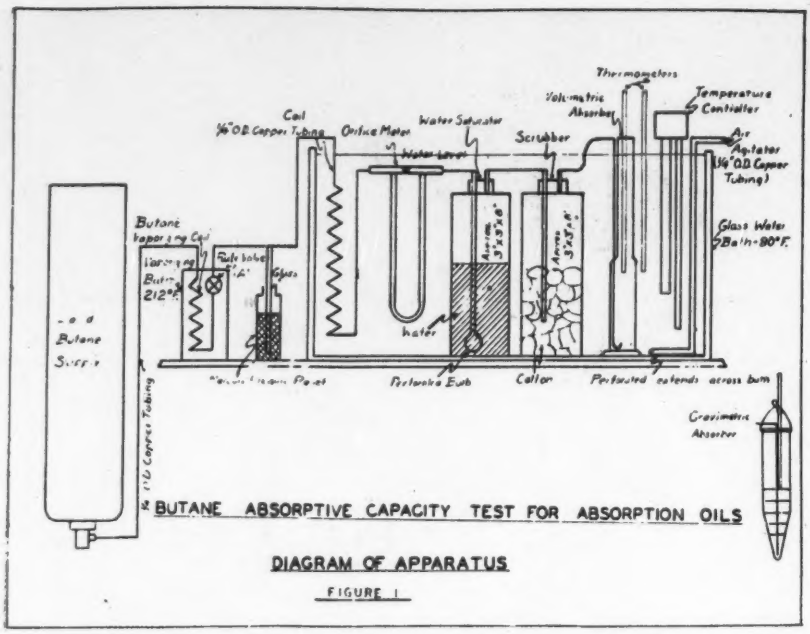
California Oil World and Petroleum Industry presents in this issue
ted at the Annual Fall Meeting

hors desire to add material, will appear in a later issue



BUTANE ABSORPTIVE CAPACITY TEST FOR ABSORPTION OILS

DIAGRAM OF APPARATUS

FIGURE 1

procedure is satisfactory for routine purposes. For establishing more precise results, the gravimetric method is preferable.

Dry Samples vs. Water-Saturated Samples

Tests were conducted on one oil using (1) dry butane vapor dehydrated oil, and (2) water-saturated vapor and water-saturated oil. Corrections for the partial pressure of water were made in the computation of results. The effect of water-saturation was indicated to be small, and since plant oils are usually saturated with water, it is considered best to standardize on a procedure requiring water-saturation of the butane vapor.

Agreement Between Duplicate Tests

In many cases repeat tests were run on the same sample. The extreme disagreement between duplicate tests was found to be of the order of 5%, or the departure from an average value was only ±2.5%. Moreover, many of the tests showing departures were obtained during the early stages of development of the method before the procedure was fully standardized. It is believed that close adherence to the final procedure as presented in this paper will yield duplicate results agreeing within one or two per cent.

Comparison of Results with Test by the Conventional Benzene Freezing Method

In all cases, "effective" D/Me values were found to be lower than corresponding D/M values based on the freezing-point method. Typical comparisons are illustrated in the table below.

Molal Concentration vs. Absorptive Capacity

Molal concentration (D/M) values determined by benzene freezing tests versus apparent or "effective" molal concentration values (D/Me) determined by butane absorption tests:

Sample	But. Abs. Meth. (D/Me)	Benz. Freez. Test D/M	% Departure from Freez. Test Value
A	0.00440	0.00448	1.8
B	0.00430	0.00460	6.5
C	0.00425	0.00470	10.4

These results indicate that the absorptive capacity determined by a method analogous to actual absorber operation may be as much as 10% lower than would be estimated from the conventional molecular weight test. In general, the more highly refined oils show a tendency to give D/Me values most closely approaching theoretical D/M results.

Conclusions

It is indicated that a molal concentration factor (D/M) such as may be determined by the benzene freezing test is not a true index of the absorptive capacity of an oil. On the other hand, the new butane absorption capacity test is conducted in accordance with a procedure which simulates actual plant absorber operation. The results are believed, therefore, to represent a more reliable criterion for evaluating the characteristics of an oil as they influence computations of absorption factors and determinations of absorber efficiency. The conventional benzene freezing-point test procedure may be considered to supply "true" molecular weights, as compared with "effective" molecular weights which are derived from butane absorptive capacity tests.

Of importance also in considering the general adoption of the new method are the facts that the test is easy to conduct and the equipment may be readily assembled in a field testing laboratory.

APPENDIX A

Butane Absorptive Capacity and Molecular Weight Test for Absorptive Oils. Procedure for Conducting Tests.

PURPOSE

1. The Butane Absorptive Capacity and Molecular Weight Test is a simple and reliable method of determining the relative absorptive capacities of oils for hydrocarbon vapors. While equally applicable to new oils, this test is particularly adaptable to wet or dirty plant absorption oils because these oils can be tested without any treatment which might alter their properties.

2. The most general usage of this test will be for the determination of the proper oil circulation in absorber operation by application of Kremser's absorption equation

$$\text{Absorption Factor} = A = 3.156\left(\frac{D}{M}\right)\frac{GP}{p},$$

D = Specific gravity of absorption oil,

M = Molecular weight of absorption oil,

G = Oil rate (gallons per 1000 std. cu. ft. of gas),

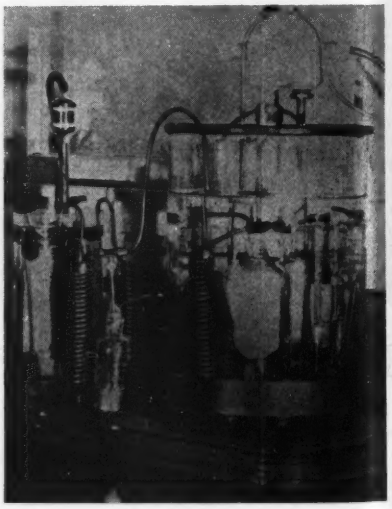
P = Absorber pressure, #/sq. in. abs.

p = Vapor pressure of gasoline fraction in #/sq. in. abs. at absorber temperature.

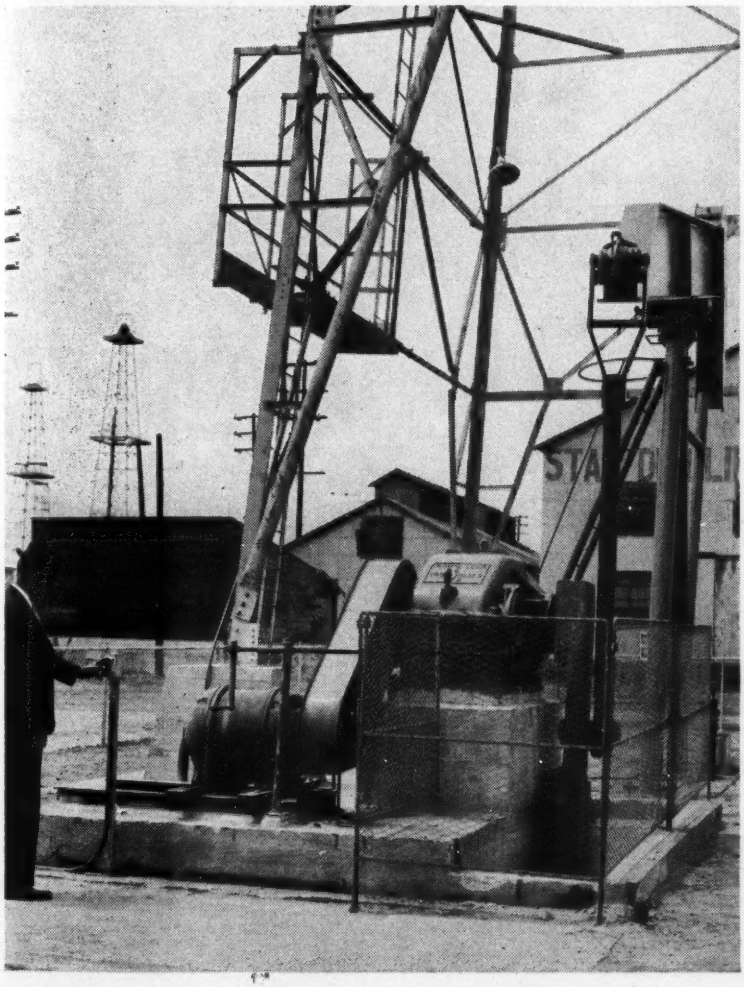
METHOD

3. A liquid isobutane - normal butane stock is vaporized (cross-cut vaporization) and passed through a quantity of absorption oil measured and maintained at 80°F. and atmospheric pressure until

Fig. 2
Butane Absorptive Capacity Test for Absorption Oils. Apparatus Assembly



WE RECOMMEND A PUNCH ON THE BUTTON



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Left: Pacific Gear & Tool reduction gear installation on Community Lease, Long Beach, driven by 15 horsepower motor.

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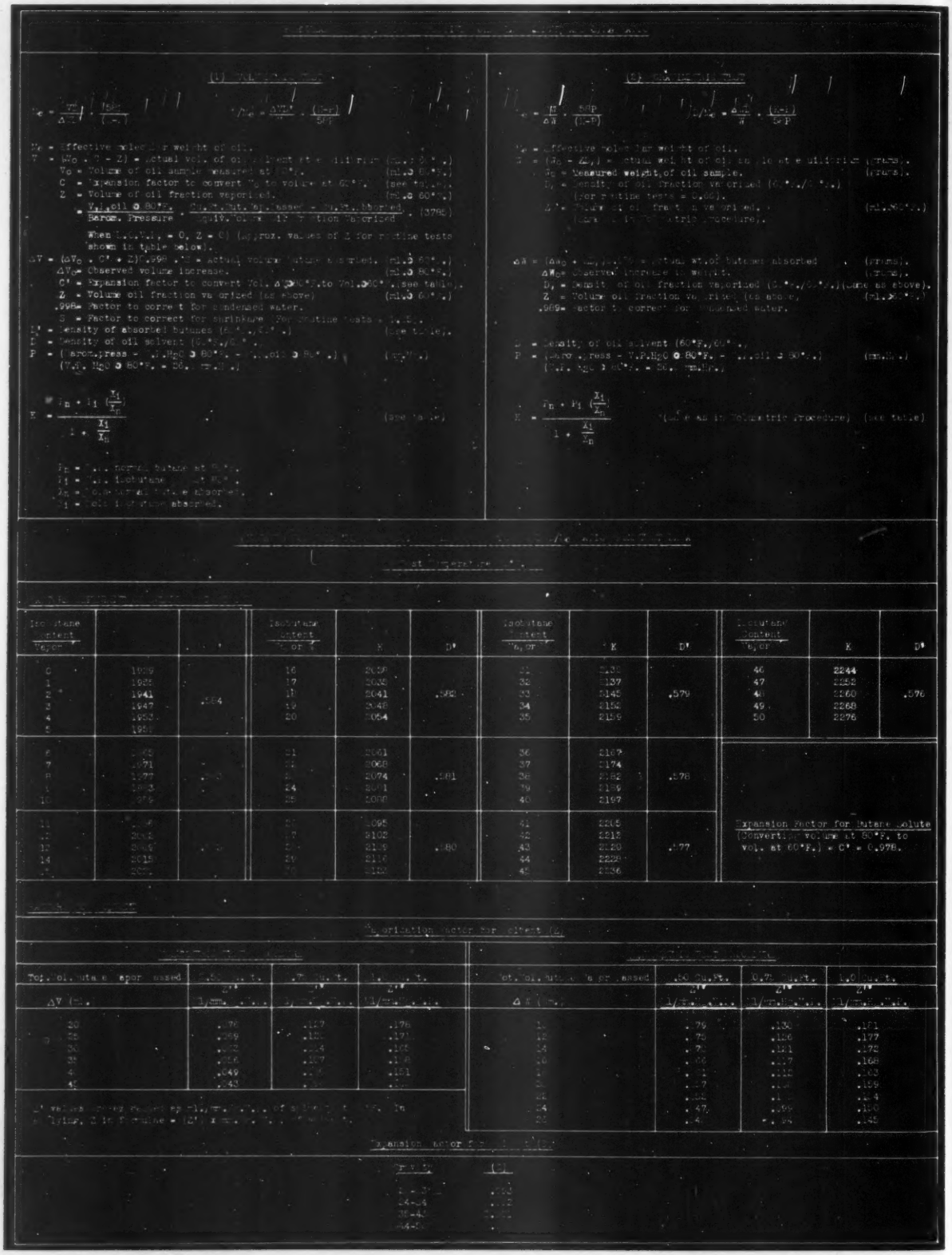
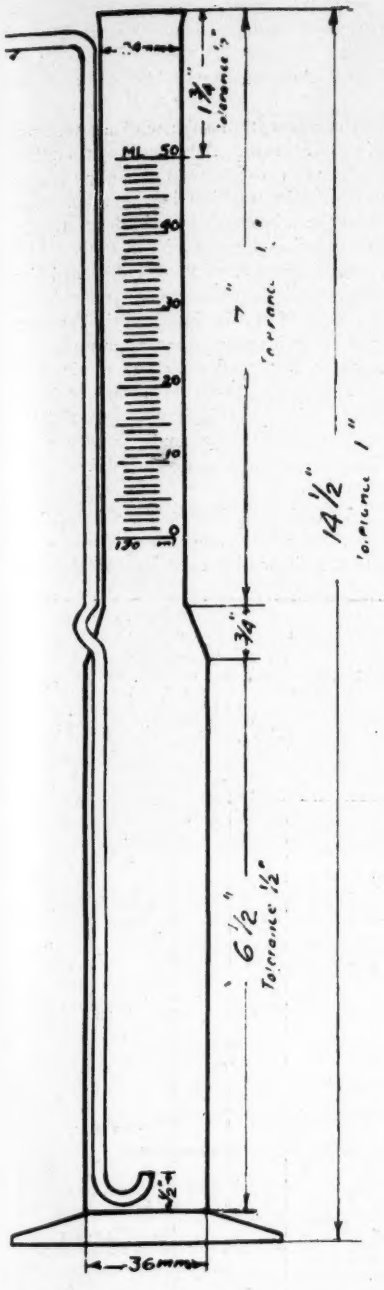
equilibrium is attained and the oil will absorb no more butane. The determined weight or volume pick-up is a direct measure of the absorptive capacity of the oil with respect to the particular solute used, and it may be used to compute generalized absorptive capacity coefficient (D/Me) and effective molecular weight values (Me). Two procedures for determining the quantity of absorption butanes are outlined below, (1) the volumetric method, and





Butane Absorptive Capacity Test For Absorption Oils—Volumetric Absorption Tube Specifications

Figure 4

All tubes shall be constructed of Pyrex glass and thoroughly annealed. All graduations shall be clear.

Dimensions shown on the tube are approximate except where tolerances are specified. The volume of the tube up to the initial graduation mark shall be 170 ml. ± 1 ml. with the exact volume (tolerance .05 ml.) etched on the tube. The graduation tolerance at any point of the scale shall be .05 ml. The volume of the 4 mm. I.D. inlet tube filled to the same level as the absorption tube shall be included in volume calibrations.

(2) the gravimetric method. Both methods have been found satisfactory.

APPARATUS AND REAGENT

Absorption Tubes Barometer

4. Specifications for absorption tubes for the volumetric and gravimetric test methods are shown in Figures 4 and 5, respectively.

5. The barometer shall be of the mercury column type and shall provide a measure of atmospheric pressure accurate to ±0.5 mm. Hg.

Balance

6. The balance, required for the gravimetric method only, shall be capable of weighing the absorption tube with an accuracy of ±0.05 gram.

Pipette

7. A 50 ml. volumetric or transfer pipette shall be provided for measurement of the oil sample in the volumetric test procedure. The volume of the absorption oil delivered by the pipette at 80°F. shall be determined with an accuracy of ±0.05 ml. This calibration factor shall be established by weighing with a new absorption oil of about 35°-40° A.P.I. gravity, and shall be applied in measuring test samples.

Vaporizing Coil

8. The butane evaporating coil shall consist of approximately 10 feet or more of ¼ inch O.D. copper tubing wound to permit immersion in the bath described below (10).

Rate Valve

9. A needle valve ((A), Figure 1) shall be provided for adjusting the flow of butane vapor to the required rates.

Vaporizing Bath

10. A water bath shall be provided for maintaining the butane evaporating coil (8) and rate control valve (9) at approximately the boiling point of water. The bath shall be of sufficient size to provide total immersion of both coil and rate valve. An electric immersion heater or a steam coil should be provided for maintaining the bath at approximately 212°F.

Pressure Relief Valve

11. The pressure relief valve (shown in Figure 1) shall consist of a mercury seal which limits the pressure on the system to a maximum of 3-4 inches of mercury. The mercury pressure relief shall be vented either to a hood or outside of the building. This is a safety factor in case the flow of butane is interrupted by a plugged orifice or line.

Equalizing Coil

12. A coil of approximately 10 feet or more of ¼ inch O.D. copper tubing shall be provided to adjust the temperature of the butane vapor to 80°F. The coil shall be completely immersed in the constant temperature bath (16).

Rate Meter

13. A small glass orifice meter shall be provided for measuring the rate of flow of butane vapor. The meter shall be completely immersed in the constant temperature bath (16).

Water Saturator

14. The butane vapor water saturator shall consist of a glass bottle, approximately 3" x 3" x 8" (see Figure 1) about half full of water. The gas inlet tube to the saturator shall extend nearly to the bottom of the bottle and shall be provided with a perforated bulb on its lower end for distribution of the gas. The saturator shall be entirely immersed in the constant temperature bath (16).

Water Separator

15. The butane vapor water separator shall consist of a bottle of about the same dimensions as the saturator, approximately half-full of dry cotton, loosely packed. The cotton shall be replaced when it becomes saturated with water. The separator shall be totally immersed in the constant temperature bath (16).

Constant Temperature Bath

16. The constant temperature water bath shall be adequate in size to allow immersion of the temperature equalizing coil, orifice meter water saturator, separator and absorption tube as indicated in Figure 1. The bath shall be provided with a means of continuous agitation and its temperature shall be **automatically maintained at 80°F. ±0.1°F. Close temperature control is a very important factor.** An electric immersion heater, connected to an ether actuated mercury tube thermoregulator, has been found satisfactory for controlling the temperature. The bath shall be of glass or shall be provided with a glass window to permit observation of the orifice meter. A cylindrical jar 12" in diameter and 18" high is sufficiently large for a double-unit set-up if the apparatus is compactly assembled.

Thermometers

17. Two thermometers shall be provided, (1) for measuring the temperature of the bath (16) and (2) for measuring the temperature of the liquid in the absorber. These thermometers shall be of the total immersion type, range 70°F. to 110°F., graduated in 1°F. divisions. A Saybolt viscosimeter thermometer conforms to these specifications.

Reagent

18. The butane reagent shall consist of a mixture of iso and normal butanes containing approximately 10% to 30% isobutane. It shall be substantially free from propane and/or pentanes (±) fractions (less than 0.2%). The composition of the reagent shall be established by

fractional analysis and the results reported in vapor per cent.

PROCEDURE

Preparation of Apparatus

19. The butane vapor saturator (14) shall be filled approximately half-full of water.

Assembly

20. The apparatus shall be assembled, except for the absorption tube, in accordance with Figure 1. In assembling the equipment, it is essential that the liquid butane supply cylinder be inverted so that a cross-cut of the liquid will be withdrawn.

Temperature Adjustment

21. The temperature of the bath surrounding the butane evaporating coil (8) shall be raised to approximately 212°F. and maintained at that point. Exact control of this temperature is not important.

22. The constant temperature bath (16) shall be adjusted to 80.0°F. ±0.1° F. and maintained at that temperature. The bath shall be continuously agitated to insure a uniform temperature at all points.

Gravity Determination

23. The gravity of the oil sample shall be determined with a hydrometer (A.S.T.M. D 287-36) and the result recorded. This determination shall be conducted with sufficient care to insure an accuracy of 0.1°A.P.I. Only certified hydrometers with scales graduated in 0.1° A.P.I. subdivisions shall be used.

V. P. Determination

24. The vapor pressure of the oil sample at 80°F. shall be determined (C.N.G.A. Procedure TS-343) and the result recorded.

Preparation of Sample

25. The oil sample shall be adjusted to 80° F. and allowed to clarify by immersion in the constant temperature bath for a period of at least 15 minutes.

Flow Rate Adjustment

26. Valve (A) (See Figure 1) shall be gradually opened and the flow of butane vapor set at the specified rate by means of the orifice meter. The rate for the volumetric test shall be approximately 0.5 cu. ft./hr. and for the gravimetric test approximately 0.25 cu. ft./hr. an extension handle is convenient for manipulating valve (A) which is immersed in the 212°F. bath.

Volumetric Absorption Method

27. One hundred and fifty milliliters of oil sample at 80°F. shall be pipetted into the previously cleaned and dried absorption tube. Water and/or emulsion should not be included in the sample withdrawn.

28. The absorption tube shall be attached to the discharge of the scrubber (see Figure 1) and butane vapor allowed to pass through the oil at the rate specified above (0.5 cu. ft./hr.). A thermometer shall be placed in the absorber and temperature observations shall be made at frequent intervals.

29. The tube shall be disconnected, the thermometer removed, and the volume read at the end of a 45-minute period and at 15-minute intervals thereafter until consecutive readings show an increase of less than 0.2 ml. It is essential that equilibrium shall be established at exactly 80°F. prior to making volume readings. A small loss in volume may be indicated after equilibrium has been reached. The maximum volume at 80°F. shall be recorded.

30. Barometric pressure shall be observed and recorded.

Gravimetric Method

31. The gravimetric test procedure shall be identical with the volumetric method (27-30), with the following exceptions:

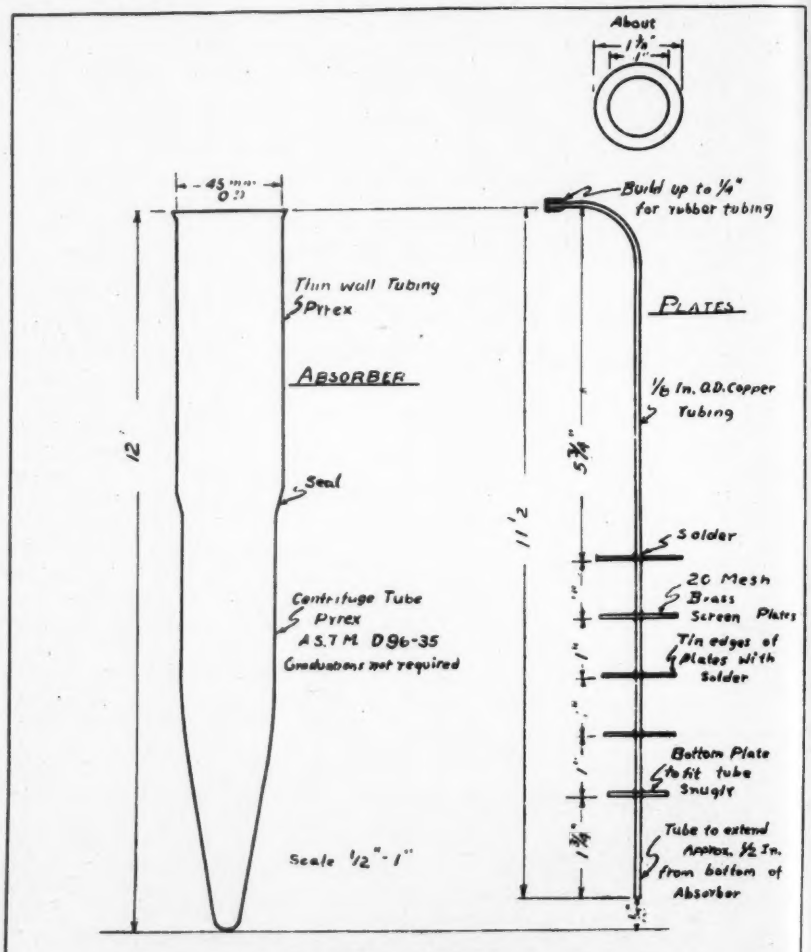
(a) The gravimetric absorption tube, containing screen plates (Figure 6) shall be used rather than the volumetric tube.

(b) Approximately 75 ml. of water-saturated oil sample shall be weighed in the absorption tube with an accuracy of ±0.05 gram. All weighings shall be made with the screen plate and thermometer in position in the tube. Care shall be observed in weighing to dry the exterior surface of the tube.

(c) The quantity of absorbed butanes shall be observed by weighing at the end of a 45-minute period, and at 15-minute intervals thereafter until consecutive observations show an increase of not more than 0.1 gram. It is essential that equilibrium be established at 80°F. prior to making weighings. The maximum weight at 80°F. shall be recorded.

CALCULATION OF RESULTS

32. The effective molecular weight and the absorptive capacity (D/Me) may


About
Build up to ¼" for rubber tubing
Thin wall Tubing Pyrex
PLATES
ABSORBER
⅛ In. O.D. Copper Tubing
Seal
Solder
20 Mesh Brass Screen Plates
Centrifuge Tube Pyrex A.S.T.M. D96-35 Graduations not required
Tin edges of plates with Solder
Bottom Plate to fit tube Snugly
Tube to extend Approx. ½ In. from bottom of Absorber
Scale ½" - 1"

BUTANE ABSORPTIVE CAPACITY TEST FOR ABSORPTION OILS

GRAVIMETRIC ABSORPTION TUBE SPECIFICATIONS

FIGURE 5

RICHFIELD
"WINTER-SHIELD"
SERVICE
A perfect cold weather automotive service, conforming to manufacturers' recommendations and protecting every vital point in your car.
In this picture, Universal's sweetheart, lovely Joy Hodges, poses with her 1939 car after its first "Winter-Shield." "I love winter in the mountains," says Miss Hodges.
RICHFIELD

be computed from test results by means of the formulae and constants presented in Figure 3.

APPENDIX B

Butane Absorptive Capacity and Molecular Weight Test for Absorption Oils. Derivation of Formulae for Computation of Effective Molecular Weight (Me) and Absorptive Capacity (D/Me).

TEST CONDITIONS

A mixture of isobutane and normal butane vapor, saturated with water vapor at T°F. and atmospheric pressure, is passed through a quantity of absorption oil, measured and maintained at T°F., until equilibrium is attained and the oil will absorb no more butanes. The determined weight or volume pick-up may then be used to compute an absorption coefficient (D/Me) and/or an apparent molecular weight value as shown below. Since the purpose is to obtain molecular weights effective in the absorption process rather than true molecular weight values, no attempt has been made to evaluate deviations from ideal relations.

NOMENCLATURE

Factors Involving Solute

X_i = Mols of isobutane absorbed at equilibrium.

X_n = Mols of n-butane absorbed at equilibrium.

W = Weight of butanes absorbed at equilibrium (grams).

V = Volume of butanes absorbed at equilibrium (ml. @ 60°F.).

D′ = Specific gravity of absorbed butanes (60°F./60°F.).

P_i = Vapor pressure of isobutane at T°F. (mm.Hg.) = 2776.8 mm. @ 80°F.

P_n = Vapor pressure of n-butane at T°F. (mm.Hg.) = 1928.8 mm. @ 80°F.

P = Partial pressure of dissolved butanes at equilibrium (mm.Hg.) = (Barometric pressure—V.P. H_2O @ 80° F.—LOVP @ T°F.) V.P. H_2O @ 80°F. = 26mm. Hg.

58 = Molecular weight of butanes.

Factors Involving Solvent

W = Weight of oil sample used (grams).

V = Volume of oil sample used (ml. @ 60°F.).

D = Specific gravity of oil (60°F/60°F.).

Me = Effective molecular weight of oil.

Formulae

(1) Material Balance:

$$X_i + X_n = \frac{W}{58}$$

(2) Butane Balance:

$$\frac{\text{Mol \% Isobutane in Solute}}{\text{Mol \% N-Butane in Solute}} = \frac{X_iP_i}{X_nP_n}$$

(3) Vapor-Liquid Equilibrium:

$$\frac{X_i}{\frac{W}{M_e} + \frac{\Delta W}{58}} P_i + \frac{X_n}{\frac{W}{M_e} + \frac{\Delta W}{58}} P_n = P$$

(4) Combining and Solving for M_e:

$$M_e = \frac{P\,W\,(P_i \pm \frac{X_i}{X_n}P_i)}{\frac{\Delta W}{58}\left[(1 \pm \frac{X_i}{X_n}P_i)P_iP_n - P(P_i \pm \frac{X_i}{X_n}P_i)\right]}$$

(5) Simplifying:

$$M_e = \frac{58\,P\,W}{\Delta W\left[\left(\frac{P_n \pm P_i\left(\frac{X_i}{X_n}\right)}{1 \pm \frac{X_i}{X_n}}\right) - P\right]}$$

(6) Let

$$K = \left[\frac{P_n \pm P_i\frac{X_i}{X_n}}{1 \pm \frac{X_i}{X_n}}\right]$$

Note: It will be observed that K is a function of the composition of the solute. That is, for a definite test temperature K remains constant for any particular solute. Values of K at 80°F. for different butane solutes are presented in Figure 3.

(7) Substituting K in (5), gravimetric test results may be computed from the following:

$$M_e = \frac{W}{\Delta W} \cdot \frac{58P}{(K-P)} \qquad D/M_e = \frac{\Delta W D}{W} \cdot \frac{(K-P)}{58P}$$

(8) For the volumetric test, equation (7) becomes:

$$M_e = \frac{VD}{\Delta VD'} \cdot \frac{58P}{(K-P)} \qquad D/M_e = \frac{\Delta VD'}{V} \cdot \frac{(K-P)}{58P}$$

In applying the above formulae to the computation of molecular weights and absorptive capacities, values for the various factors not directly measured may be obtained from 80°F. test results in the following manner:

$V = (V_c \cdot C - Z)$ = Volume of oil solvent at equilibrium (ml.@60°F.)
- V_c = Vol. of oil solvent measured at 80°F. (ml.)
- C = Expansion factor to convert V_c to vol. at 60°F.
- Z = Volume of oil fraction vaporized (ml. @ 60°F.)

$$= \frac{\text{V.P. oil @ 80°F.}}{\text{Barom. Pressure}} \cdot \frac{\text{Cu. ft. but. vap. passed} - \text{cu. ft. absorbed}}{\text{Equivalent volume oil vaporized}} \quad (3785)$$

(When V.P. oil = 0, Z = 0)

$\Delta V = (\Delta V_c \cdot C' \pm Z)0.998 \cdot S$ = Actual vol. of butanes absorbed (ml.@60°F.)
- ΔV_c = Observed volume increase (ml. @ 80°F.)
- C′ = Expansion factor to convert V_c to vol. @ 60°F.
- Z = Vol. of oil fraction vaporized (as above)
- S = Factor to correct for volumetric shrinkage (for routine tests = 1.05)

$W = (W_c - ZD_1)$ = Actual weight of oil sample at equilibrium (grams)
- W_c = Measured weight of oil sample (grams)
- D_1 = Density of oil fraction vaporized (60°F./60°F.) (For routine tests = 0.66)
- Z = Volume of oil fraction vaporized (ml. @ 60°F.) (Same as in volumetric procedure above)

$\Delta W = (\Delta W_o - ZD_1)$ = actual weight of butanes absorbed (grams)
- ΔW_o = Observed increase in weight (grams)
- D_1 = Density of oil fraction vaporized (as above)
- Z = Volume of oil fraction vaporized (as above)(ml.@60°F.)

$$K = \frac{P_n \pm P_i\left(\frac{X_i}{X_n}\right)}{1 \pm \left(\frac{X_i}{X_n}\right)}$$

$$X_i = \frac{\text{Mol \% Isobutane in Solute}}{\text{Mol \% N-butane in Solute}} \cdot \left(\frac{P_n}{P_i}\right)(X_n)$$

$X_n = (1.0 - X_i)$

P_i = 1928.8 mm. Hg. @ 60°F.

P_n = 2776.8 mm. Hg. @ 80°F.

C. N. G. A. Technical Committee Lowers

Price of Bulletins to Membership

By Earle W. Gard

The California Natural Gasoline Association is an organization founded for the purpose of creating a common meeting ground upon which its members may assemble to discuss matters of mutual interest. To further this aim, a representative group of the membership is annually selected and charged with the responsibility of providing a program of discussion on those technical problems relating to methods of tests, testing procedures and other related subjects. This selected group of members has been designated as the Technical Committee.

To convey some idea of the magnitude of the program carried on by this committee, it may be well to state a few facts regarding this work.

The present Technical Committee is made up of seventeen members representing a like number of companies engaged in the production of natural gasoline or, in some manner, associated with its production. The activities of the main committee are carried on through various sub-committees and the personnel of these sub-committees consists of seventy-nine members who have been selected from thirty organizations. Each man in this entire group has been selected because his training has qualified him for the assignment. Each sub-committee is assigned a separate problem and the work is coordinated through the sub-committee chairmen. These sub-committees plan to meet at least once each month for the purpose of discussing the progress of the work. The enthusiastic support these men have given the programs outlined by the Technical Committee has made it possible to accomplish an enviable amount of work, which has received noteworthy recognition by the industry.

The Technical Committee has been engaged in the development of Standard Tests and the preparation of Tentative Standard Procedures for those tests conducted on natural gas, natural gasoline and other hydrocarbon mixtures extracted therefrom. These tests have included volumetric measurement, determination of physical properties, separation of mixtures into component parts, and the determination of the extractable gasoline content of natural gasoline. The recommendations of this Committee have included specifications for the standardization of products and, insofar as practical, the standardization of technical data and engineering practices.

The California Natural Gasoline Association Technical Committee has been closely associated with other kindred organizations such as the American Society for Testing Materials, American

EARLE W. GARD

Petroleum Institute, Natural Gasoline Association of America, American Gas Association, Pacific Coast Gas Association and Southern California Meter Association, all of which are striving toward standardization.

Since 1928 the Technical Committee has completed and released for distribution eleven bulletins, eight of which are still available and may be purchased from the Association's Secretary. Two bulletins are now out of print, one has been replaced with a revision and two are being revised. There is also the "Master Bulletin" which is a compilation of all active bulletins and is available from the Secretary.

The price of the bulletins has been altered recently to conform to the prices asked for similar publications and a special price has been set for paid-up members of the Association.

Bulletin Number	Title	Non-Member	Member
311	Tentative Standard Method for Analyses of Natural Gasoline by Fractional Distillation	$1.50	$1.00
321	Tentative Standard Method for Analysis of Natural Gas by Fractional Distillation..	$1.50	$1.00
341	Tentative Standard Method for Gauging Natural Gasoline in Pressure Storage....	$1.50	$1.00
342	Tentative Standard Procedure for Sampling Natural Gas and Gasoline	$1.50	$1.00
343*	Standard Procedures for Testing Lean Absorption Oil	$1.50	$1.00
351**	Tentative Standard Procedure for the Charcoal Test for the Determination of the Gasoline Content of Natural Gas	$1.50	$1.00
352	Tentative Standard Method of Test for the Reid Vapor Pressure of Natural Gasoline	$1.50	$1.00
353	Tentative Standard Procedure for the Measurement of Natural Gas with Orifice Meters	$2.50	$2.00
354**	Tentative Standards for the Determination of Super-expansibility Factors in High Pressure Gas Measurement..	$2.50	$2.00
381	Tentative Standard Method for Proving Positive Displacement Meters to Measure Natural Gasoline	$1.50	$1.00
	Master Bulletin	$20.00	$15.00

* Only a few copies on hand.
** Out of print.

For the benefit of those who are not familiar with the "Master Bulletin", may I state that this publication is sold under a plan which provides the purchaser with a service that automatically keeps him advised of all corrections and revisions. He is also informed of the publication of all new bulletins.

During the past year, one Bulletin, No. 381 "Proving Procedure for Positive Liquid Displacement Meters for Measurement of Natural Gasoline", has been completed and is available for the first time, today. Two other bulletins are now in the hands of the Editorial Sub-Committee. One of these, "Tentative Standard Methods of Determining the Specific Gravities of Gases", describes proposed procedures and standard types of apparatus for the determination of specific gravities of gases. The other, "Specifications and Tentative Standard Methods of Test for Liquefied Petroleum Gas", outlines the procedures of test and the proposed specifications for liquefied petroleum gases. These two bulletins will be available in the near future.

Other publications in the final stages of completion consist of a compilation of physical constants and other engineering data on petroleum liquids and vapors, and a bulletin on Safety which outlines practices for the operation and maintenance of absorption and compressor plants.

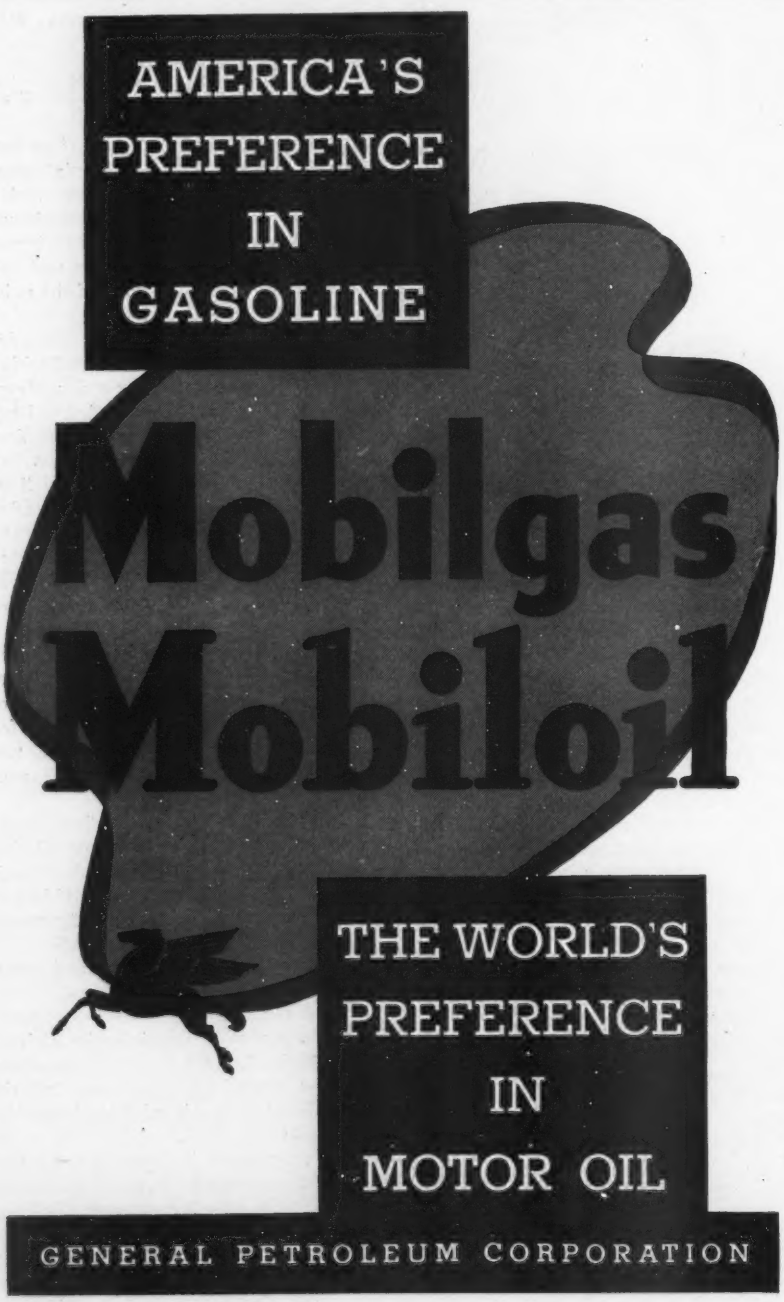
Sub-committees of the Technical Committee are also engaged in the revision of Bulletins TS 311 and TS 321, which will be combined into one bulletin, "Fractional Analysis of Petroleum Vapors and Liquids". Additional work now in progress includes a condensed working procedure of Bulletins TS 353 and TS 354, Gas Measurement and Super-expansibility Bulletins, which will permit a more general application of the principles of gas measurement that have

been set forth in these two publications. This work will be handled by a joint committee, members of which will be representatives from the California Natural Gasoline Association, Southern California Meter Association and Pacific Coast Gas Association.

Bulletin TS 351, "Tentative Standard Procedure for the Charcoal Test for the Determination of the Gasoline Content of Natural Gas" is being reviewed for the purpose of improving the accuracy of the test and making recommendations which will result in a more general application of this important test.

The problems now under consideration by other committees are: Recommendations for improved sampling cylinders and methods of sampling; preparation of a bulletin giving data on compressor operation, and the standardization of the storage containers and fittings for the handling of liquefied petroleum gas for domestic and truck service.

The accomplishments of the Technical Committees as a whole, have been among the outstanding achievements of the California Natural Gasoline Association and I am sure that you all appreciate their efforts in your behalf in prosecuting so successfully the work undertaken. The world wide distribution of the bulletins so far released attests to the importance of the results accomplished, and the enthusiastic support given by the industry to this work will serve as an inspiration for even greater efforts in the future.



Byron Jackson Blocks Tool Patent Infringements

Following the recent filing of a patent suit by Byron Jackson Co. in the United States District Court at Oklahoma City, the defendants, McKee Supply Company and O. B. McKee, dealers in second-hand oil well equipment at Oklahoma City, have been enjoined, pursuant to a consent decree, from continuing their practice of making up for sale oil well pipe and casing tongs employing parts of used Byron Jackson tongs, assembled with or without one or more parts made by the defendants. The decree finds that the defendants had infringed the patents of Byron Jackson Co. as follows:

"By making and selling individual parts and elements of said tongs, with the intention that the same were to be assembled in pipe and casing tongs embodying and containing the inventions of said letters patent as set forth in said claims thereof; that said defendants have infringed said patents by purchasing or otherwise acquiring used or worn out pipe and casing tongs and parts thereof manufactured, assembled and sold by the plaintiff, and by disassembling said tongs and parts into their elements, and from the parts of different tongs so disassembled, constructing and selling complete tongs and tong heads; that said tongs and tong heads so constructed and sold by the defendants do not preserve the identity of any original tongs or tong head manufactured, assembled and sold by the plaintiff; and that the defendants have infringed all of the claims of all of the said patents above named under the guise of repairing the tongs manufactured and sold by the plaintiff, by rebuilding worn out tongs, tong heads, and parts thereof, and selling the same."

In obtaining this injunction, Byron Jackson Co. has invoked a remedy accorded by the patent laws which, though well established by prior court decision, has not heretofore been sought in the oil equipment industry. This action by Byron Jackson Co. may be followed by similar action by other oil field equipment manufacturers in an endeavor to properly protect their patented lines.

Federal taxes take the pay of one worker for every man added to motor company pay rolls.

More than 1,000,000 miles* of Service in 1938

BY THE END OF 1938, Perkins motorized cementing equipment will have traveled more than one million miles serving the oil industry in ten Western States. This is more than the equivalent of two round trips to the moon.

Such widespread acceptance of Perkins service can only be accounted for by the fact that operators throughout the West will accept no substitute for the proved superiority of Perkins cementing methods, equipment.

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*MORE THAN THE EQUIVALENT OF TWO ROUND TRIPS TO THE MOON

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Back of every Perkins Cementing J
is the accumulated experience
28 years of serving the oil industr

Advances in Compressor Plant Operation

and design Noteworthy

By T. HUME WEST

The importance of compressor plants in the oil and gas industry probably does not have to be pointed out to men in that industry. However, it is interesting to see how, as the industry has grown, the number of plants and units has increased, and what changes in them have taken place. In this paper we intend to review briefly compressor plants in general and compressor units in particular, showing advances in their design, operation, and maintenance, and the advantages and benefits of these improvements.

The accompanying Chart No. 1, compiled from data supplied through the courtesy of the leading manufactures of engines and compressors, shows approximately the number of the different types sold in California in recent years. It will be seen that the units have been divided into three main groups: compressors belt-driven by separate engines, horizontal direct connected units, and vertical angle type; also that the trend of installations has been progressive through these groups. Assuming that most of the older units are still in use, we can see that the quantity of units is constantly increasing. It is almost inevitable that this quantity will continue to increase, but both to the discovery and development of new fields, and to declining pressures in the existing fields. These declining pressures probably will require more plants, not only to carry on field operations, but also for deliveries of gas from the fields, as the initial pressures become inadequate. Thus, it seems that compressor plants and the modern improvements we can make in them are due to become increasingly important. Their importance is shown also by the estimated value of the plants, shown in Table No. 1 to be a surprisingly large figure in total.

Up to about 1923 the main compressor units usually consisted of a compressor driven through a long belt by an ordinary "stationary engine". The engines were usually two-cylinder, two or four cycle, and generally operated at speeds of from 150 to 200 r.p.m., with strokes of 16 to 20 inches. These belt driven units usually ranged in size from 100 to 175 h.p., but there was some tendency to over-rate them. Altho it was possible to attain the rated RPM in continuous operation, the general practice of the field operators was to maintain about 80 or 90 per cent of the rated figure.

Many of these units are still in active service today, faithfully pumping millions of feet of gas, but their disadvantages were numerous. The long belt drives required much space and large buildings. They were expensive to buy, troublesome to maintain without slipping, difficult to keep clean and neat, and required bulky and awkward guard rails. The chance of a belt breaking was a constant danger to the men and equipment, as well as a threat of a shut-down of from one to several hours when most needed. The large belt wheels on both engine and compressor brought up the same objections of size, guard rails, and the difficulty and danger of keeping them clean. In addition to the belt wheel, the engine usually had a twin wheel on its opposite side, the two of them acting as flywheels, but also taking more space, guard rails, and power.

The next units to come into general use, about 1923-25, were the direct connected engines and compressors. In spite of considerable reluctance of some manufacturers to change to this type, due to their belief it would not be a practical or durable design, they all did change eventually. These units comprise the largest portion of horsepower in our California plants, and are still being sold, tho not so frequently as in the past. These were made in both one and two cylinder, two and four cycle types, usually operated at speeds of from 150 to 200 r.p.m., with strokes of 20 to 24 inches, and covered a much wider range of horsepower. This type varied from a few one cylinder 50 h.p. units up to about 250 h.p. in the single acting twin units, and then on up to around 1000 h.p. in the double acting twin tandem units. These machines brought the advantages of compactness, freedom from belt troubles, and a much wider choice of sizes and horsepower. For these reasons they have been, for several years, practically the standard machines for compressor plants.

During this same period several improvements were made in the design of the two cycle power cylinder. These were the perfection of the fuel injector or economizer, giving fuel consumption about equal to that of four cycle units; scavenging air pressure and power was reduced about 30 per cent while its effectiveness was increased; cylinder and piston cooling was improved to an extent making it possible to increase the cylinder bore from 16 to 17 inches and develop BMEP within about 10 per cent of that common to similar four cycle engines. These improvements enabled the manufacturers to offer a 250 h.p. unit on the frame formerly used for 165 to 170 h.p. engines, at about a 20 per cent reduction in installed h.p. cost.

Recently a third type of unit has been developed, and is bidding for first choice in the newer plants. This is the vertical-angle type, in which the power cylinders are vertical or in a V form and the compressor cylinders are horizontal, both operated from the same crankshaft throw by articulated connecting rods. These units have from two to eight power cylinders, either two or four cycle, and from one to four compressor cylinders. They vary in size from 75 to 800 h.p., and operate at speeds of from 300 to 350 r.p.m., but with piston speeds remaining within 11 to 12 feet per second. These units brought the advantages of further compactness, lighter weight, and thus greater ease in moving when necessary, lower cost, and greater economy in plant design. They take only about half the floor space of the horizontal units, and since they have only one small flywheel which can be completely enclosed, and their piping is more centralized, they can be run in a double row in an ordinary size building, or lined up in a way to best meet the requirements of the individual plant.

Auxiliary power units have come in for their share of remodeling too. While they may not attract so much attention, nevertheless modernized units are available and often well worth investigating. In the old days it was usually customary to set up a couple of fair sized engines and drive all of the auxiliary equipment, such as water pumps, air compressors,

CHART NO. 1
SURVEY SHOWING APPROXIMATE NUMBER AND H.P. OF GAS COMPRESSORS IN CALIFORNIA OIL FIELDS

Type of Unit	No. of Units	Total H. P.	Approx. Period Installed	Estimated Plant Values
A. Engine and Compressor, belt driven	931	141,500	1915 to 1925	$ 18,500,000
B. Horizontal, direct-connected	789	161,855	1925 to 1935	16,200,000
C. Vertical-angle type	200	46,965	1935 to date	3,400,000
Totals	1920	350,320		$ 38,100,000

generators, plant shop tools, etc. from them through an elaborate system of line shafts, belts, and pulleys. Sometimes this forest of belts, shafts, and all the necessary guard rails took up as much space as three or four main compressor units. Now, however, compact self-contained or direct connected units of one type or another are available for all of these purposes. They vary from the one or two cylinder vertical moderate speed type to the four and six cylinder, and even V-8 heavy duty automotive type; can be had in speeds of from 500 to 2500 r.p.m., and generally can be adapted to operate on either liquid or gas fuel. Their small, compact size and almost all enclosed, self-contained features, make possible their installation in much less space than before. They also are much neater in appearance, easier to clean around, and much safer to work around, due to the absence of the large flywheels, pulleys, and belts.

Miscellaneous auxiliary equipment also has been subject to much improvement over that used in the early plants. Water pumps in those days were commonly of the bronze-bushed, single suction, fairly low speed type. If their impellors became a little worn, their efficiency dropped down as low as 60 or 70 per cent, and their output dropped correspondingly, sometimes resulting in cooling problems in the plant. Now, ball-bearing, double suction, enclosed impellor, high speed pumps are available with efficiencies of between 80 to 90 per cent. These can be direct connected to the modern high speed power units, or driven by the other types.

Cooling towers have become pretty much standardized since the days of spray ponds and cooling towers with a wide variety of louver designs. Spray ponds are seldom seen in new plants, and the cooling towers have considerable uniformity in their appearance and design. The tower louvers, spray racks, water distributing and collecting systems have been much improved, resulting in better cooling and less wind loss. This reduced wind loss has been an advantage both in the quantity of water used and in lower maintenance around the plant, due to elimination of the corrosive spray. The old cooling coils, so often made of banks of ordinary 2-inch pipe, are now largely replaced by brass tube coils. These, with proper water distribution, not only give better cooling, but lower maintenance costs due to their corrosion resistance. Being much more compact for the same cooling capacity, and made in standard sizes, they permit more flexibility of arrangement, and easier removal from one location to another when necessary.

Mufflers are another item which have undergone considerable change since the days when the engines often were allowed to bark unmuffled into the open air, or perhaps were quieted a little by the steam resulting from the water injected for cooling the exhaust pipe. Mufflers then usually consisted of concrete vaults or pipes with slots, holes, or baffles, in arrangements as varied as the number of their designers. All of these, however, were more or less inefficient, and since nearly all of them used water, with its attendant troubles, they were expensive to operate and maintain, not only in themselves, but the spray and steam blowing over the plant caused higher maintenance cost all around.

Practically the only more satisfactory muffler available both then and now almost without change has been a certain patented silencer. This has been available in different degrees of muffling and a variety of shapes and sizes. The other principal improvement in mufflers has been a patented air cooled type. This was developed locally in Southern California, and is available in sizes for all types of engines. Using for cooling, instead of water, a strong blast of air sucked out of the engine room, it not only cools itself without cost, but also provides better engine room ventilation and eliminates the damaging spray and steam of the water cooled types. These are now used widely in many plants, both here and in other parts of the country.

Improvements also have been made in the header and piping systems in compressor plants. Modern materials have contributed much to this advance. Lubricated plug valves instead of gate valves now provide quicker, easier operation and positive shut-offs. Sensitive pilot-controlled back-pressure regulators are now used sometimes in addition to pop valves on the plant discharge, giving more accurate, safer control, and eliminating the leakage often present in poorly maintained pop valves. Welding fittings, in all the variety now available, are a great improvement over the old cast iron, bolted fittings. They permit the extremely high pressures now coming into use and usually provide far more safety than the comparatively brittle cast iron fittings did in the past. They also are more compact and lighter in weight, thus permitting better design of the piping layout. In speaking of pressures, we may remember that we used to have trouble in getting cylinders for more than a few hundred pounds discharge. Now, however, cylinders are in use at 3500 to 4000 pounds pressure, and the manufacturers say they can build up to 5000 pounds without trouble.

The foregoing covers the principal advances in equipment and design, so now let's talk briefly of operation and maintenance. Of the devices for improving and checking the operation of the engines and compressors, the indicator probably comes first. Of course, it has been available for years, but it is perhaps better known and more widely used and understood now. More recent developments are the neon timing indicators and the exhaust gas analyzers. The first permits accurate ignition timing and the second, accurate fuel mixture analysis, both under actual operating conditions, thus enabling the best adjustment of these two vital factors.

Another device or practice perhaps used more widely now than in the past is that of load control with variable clearance. Many of the new compressor cylinders have this feature built in, or much the same effect can be secured on many of the older cylinders by the addition of outside clearance bottles. In this way the same cylinders can be used to cover a wide range of intake or discharge pressures, thus securing almost constant load, or at other times eliminating the purchase of new cylinders for a slightly different pressure range.

In the way of maintenance, there are several ideas whereby we can modernize and improve our old units. Starting with the oldest type—the long belt drive, we remember that later the spacing between engine and compressor was often shortened and an idler pulley added. This saved a great deal of space, but the idler was a nuisance, and the reverse bend in the belt caused more wear and tear on it. So the idea was tried of doing away with the idler and using a tight belt on the same short centers. With the usual large wheels and the belt maintained clean and in good condition, operation was found to be successful, and now quite a number of units are operating satisfactorily that way. The result has been a considerable reduction in space and in the first cost and maintenance of the belts.

A trouble sometimes found in these old engines with a heavy flywheel on both ends of a double-throw crankshaft was that of frequent and often disastrous breaking of the crankshafts. The idea that excessive torque stresses might be due to the inertia of these heavy wheels was thought of, so the wheel on one end was removed, leaving only the belt wheel on the other end. It was found that the engine operated very satisfactorily, so this change was tried on quite a few units. To my knowledge, broken crankshafts have since then become practically a thing of the past on these engines.

Most of the earliest 4-cycle units were supplied with cast iron valves. Later on most of these were furnished with steel valves, giving much better life. Replacing of the old valves as they burn out now can be done easily with steel valves, bringing this item up to modern practice. Another point along this line is that facing the valve seats with special hard alloys, again to provide longer life and better efficiency. With modern welding practice and materials this feature also can be added to old units.

Many old units used fairly wide piston rings in both engine and compressor. Admitting that this question of ring design is still somewhat controversial, we do know also that several operators have found marked success with much narrower rings than formerly used. Indications are that their use may contribute materially to the reduction of rings and cylinder maintenance costs. In this connection the practice of honing cylinders after reboring also has been found to be well worth the cost in many cases. Prolonged life of rings, pistons, and cylinders in these cases has more than offset the additional cost of the honing job.

Many of the early engines used oscillating magnetos for ignition. The prevailing practice now is to use rotary magnetos, even on the horizontal direct connected units, and obviously on the higher speed, multi-cylinder units. In many cases when the old oscillating magnetos needed a major overhaul they have been replaced with the newer rotating type instead. This usually can be done without serious rebuilding of the unit, and the result is more accurate, better, and modern ignition.

In the early two-cycle engines the fuel is mixed with the incoming air before compression. Due to the fact, however, that this mixture also did the scavenging, there naturally was a certain amount of fuel lost in this process. To overcome this loss, the principle of injecting the fuel at about 15 lbs. pressure in the head of the cylinder just as the scavenging ended was perfected. Fuel economy practically equal to that of four-cycle units was then possible, and most of the later two-cycle units were so equipped. Fuel injector type heads and accessories were then made available for many of the older engines, so that when it became necessary to scrap old broken heads they could, at some additional cost, be replaced with the new type. Their fuel economy then became comparable with the newer units, and they secured the added improvement of the more durable steel heads at the same time.

Forced feed lubrication of reciprocating parts is an item which is probably much more common in modern units than in the old ones. As everyone knows, lubrication is subject to much variation and controversy, so that the advantages of adding forced feed lubrication to old units perhaps are best decided for each individual case.

Another device for securing safer and better maintenance is that for testing metal for fractures. Formerly this was done almost entirely by visual observation with whiting. Now a device for finding fractures magnetically is available, making possible the detection of flaws invisible under the old methods.

Apparent cost trends of modern plants compared with old ones are shown quite clearly in Chart No. 2, along with considerable other data as to horsepower ranges, etc. of the various types of units. This table was compiled by the Compressor Committee from work initiated by Lyman Scheel, well known for his other work for the Association. Since the new vertical-angle type compressors have not been out long enough to obtain the amount of operating and maintenance cost data that is available for the other types of units, positive answers to these questions cannot be given at the present time. However, certain facts as to unit cost, space, weight, building and foundation sizes, and installation costs are available now, and the results of these have been reduced to percentages and are shown in this chart. These show that the trend to reduced costs definitely follows the newer units.

The cost of moving units from one location to another is also in favor of the new style units. Being so much more compact and lighter in weight, they can often be moved without the slow and expensive dismantling and reassembling usually necessary with the old larger types. Also, the cost of new foundations and buildings, and the loss of investment in the abandoned ones, is less for these units.

The expected life, depreciation, and obsolescence of these new types still remain to be seen, but these factors presumably should not differ greatly from the old units. Since some of the old timers are still running after 20 or 30 years, obsolete as they may be, these new ones should last quite a while. Obsolescence, in these rapidly changing times, remains to be seen, but even now experiments are being made on rotary type direct connected engines and compressors. Whether these, or some still different type, will be the units of the future, only time will tell.

Meeting in San Francisco for the first time in eleven years, Ernie Smith (left) and Emory Bronte (right) talked over their famous 25-hour and 3-minute flight from the mainland to the Hawaiian Islands, July 15-16, 1927. Bronte is now with Tide Water Associated Oil Co. as sales agent. Smith, who piloted the plane, returned to follow his career with the Maddux Air Lines, later merged with Transcontinental & Western Air, Inc.

The gravimeter, "divining rod" of modern prospecting, is made of aluminum wire so delicate that it would take 108,000,000 feet of it to weigh one pound.

CHART II

ECONOMIC RESULTS OF ADVANCE IN COMPRESSION DESIGN

Type of Compressor	Power Unit	Engine Cycle	Average Unit Rated BHP	Rated BMEP	Normal Operating BMEP	Ultimate Operating BMEP	Relative Power Weight	Relative Foundation Required	Relative Floor Space	Relative Unit Power-Cost	Relative Installation Cost per BHP
A—Belted	Horizontal or Vertical	Four	160	74	63	70	275%	270%	580%	205%	200%
B—Belted	Horizontal	Two	160	45	36	45			450%*		
C—Direct Connected	Horizontal	Four	170	66	66	72	230%	250%	260%	135%	145%
D—Direct Connected	Horizontal	Two	165	43	45	55	255%	290%	270%	115%	140%
E—Direct Connected	Horizontal	Two	250	55	55	65	175%	200%	175%	100%	110%
F—Angle Connected	Vertical	Four	300	75	75	81	100%				
G—Angle Connected	Vertical	Two	300	60	60	72	110%	100%	100%	100%	100%

*—Idler Equipped, with 11'-6" shaft centers.

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COALINGA, DOMINGUEZ, MARTINEZ, WILMINGTON

GULF COAST

HOUSTON, TEXAS; NORCO, LA.

MID-CONTINENT

EAST CHICAGO, IND.; WOOD RIVER, ILL.; ARKANSAS CITY, KANSAS

LAUGH THIS OFF

Safety is so much an obsession with oil men that we know one fellow who always keeps a little water in the house in case of fire.

And it's a peculiar thing, says **Abe Rush,** that all of the inside stories about the oil industry are developed by outsiders.

It's really high time that something was done to dignify this business. **Byron Slater** ran across a Long Beach chap working in a pump station recently, and remarked, "Why I didn't know you worked here!" "Oh yeah," answered the lad, "but for goodness sake don't tell my folks. They think I'm a bartender in a night club."

In this connection, a group of the C.N. G.A. boys were chattering in the hall after a recent meeting. Says one rather voluble individual, "Whenever I get down in the dumps I always get a new suit." Says **Bob Crippen,** "Oh, so that's where you get them!"

Continuing on the same subject, we read somewhere a short time ago that men's socks are being made with glass wool, and rather imagine it's going to be fun watching the little lady puttying up the holes.

Charlie Sherertz was commiserating with a field man who was evidently pretty low down physically. "I ate a half-dozen oysters about three nights ago," he said, "and I've been feeling punk ever since." "Maybe there was something the matter with them," suggested Charlie, "How did they look when you opened them?" "Gee," moaned the victim, "Are you supposed to open them?"

And this actually happened at Huntington Beach, according to **Geo. Grady,** "What's your name again?" asked the gauger, and the pumper replied, "Pamferdunck." "Excuse me for laughing," continued the tape juggler, "but I thought at first you were saying 'Pamferdunck'."

At a recent meeting of gas men, a speaker on world topics was orating with much gusto. "If we don't take steps to prevent it," he yelled, "The colored races will control the world—and who will carry the white man's burden then?" From the back row **Bo Thibodeaux** suggested, "The caddy, same as usual."

Which recalls **Tom Taggart's** classic remark after he looked through the Griffith Park telescope at the moon. Turning away Tom shook his head, and murmured, "Nope. It won't do. Too many bunkers."

And **Hal Halvorsen** was on his favorite topic—the earthquake. "Suddenly the house started to dance," he said, "and cups and saucers flew all over the place." Whereupon the production foreman jumped up and, clapping his hand over his breast pocket, remarked, "That reminds me, I haven't mailed my wife's letter."

Habit is strong with most of us. Ordering beets with his lunch in a wayside cafe, **Dick Hoover** says, "Gimme a stack of reds."

And an indication of the trend of the juvenile mind may be found in this story by **Henry Brett.** Driving along Whittier Boulevard a few nights ago, Henry was stopped by a little kid who was gesticulating furiously in the middle of the road. "What's the trouble?" he asked as he slammed on the brakes. "Shut up, and show me your driver's license," growled the youngster, "We're playin' at motor cops."

Incidentally, speaking of kids, Junior flunked his geology quiz last week. He thought lava was what the barber puts on your face.

Elwood Hedges now tells us there is a tailor down in Compton who will make a suit of clothes for you while you wait. All you have to do is put in your order and then go home and wait.

With which we conclude. Remember, the most difficult thing in the world to regulate is a shower bath in a boarding house.

Use me to—BRING IN WELLS EASILY—GET GOOD CEMENT JOBS— SET LARGER CASING OR LINER — STRAIGHTEN CROOKED HOLE—GET BOTTOM WATER SHUT-OFF—ENLARGE HOLE FOR GRAVEL PACKING—DETAILS ARE IN THE BAKER SECTION OF YOUR COMPOSITE CATALOG.

BAKER ROTARY WALL SCRAPER

State Drilling Report

Field	Company	Well	No.	Sec.	Twp.	Range
		NEW WELLS				
Wilmington	Bond Petroleum Corp.	Mutual	2	35	4S	13W
Rosecrans	Hydrocarbon Products, Inc.	Cole	1	19	3S	13W
	W. E. Entrikin, Trustee		D-1	7	3S	13W
	Univ. Cons. Oil Co.	Universal-Trust	14	18	3S	12W
Ventura	Tide Water Assoc. Oil Co.	Lloyd	123	27	3N	23W
	Tide Water Assoc. Oil Co.	V. L. & W.	40	25	3N	23W
Belridge	Belridge Oil Co.		25–26	26	27S	20E
	Belridge Oil Co.		26-A-35	35	27S	20E
Torrance	Alford Oil Co.		11	23	4S	14W
	The Texas Co.	Oakley	2	30	4S	13W
	Ring Oil Co., Ltd.	Ring-Hawkins	5	25	4S	14W
	Felix Mallon	Mallon	2	23	4S	14W
	Paso Oil Co.	Lyle	1	22	4S	14W
	Plymouth Oil Co.	Plymouth	1	23	4S	14W
	Standard Oil Co.	Marble	2–11	22	4S	14W
	D & B Oil Co.	D & B	2	25	4S	14W
Montebello	Union Oil Co.	Calkins	1	2	2S	12W
	Olympic Refining Co.	Smith Comm.	1	2	2S	12W
Los Angeles Co.	Mangrum & Page	Lintz	1	4	3N	15W
Sespe	Crystal Oil Co.	Crystal Oil	1	35	5N	20W
Rincon	C. C. M. O. Co.	Hobson	A-6	15	3N	24W
Poso Creek	E. S. Brooks	Smith	1	34	27S	27E
Kern Co.	The Superior Oil Co.	KCL	12	3	30S	26E
	Federal Drilling Co.	Base & Goodknight Glide	4	13	26S	27E
	Dr. F. M. Pottenger	Villard	1	2	26S	28E
Fruitvale	Western Gulf Oil Co.	40-KCL-B		22	29S	27E
Mt. Poso	W. P. W. Petroleum Co.	Glide	1	19	26S	28E
	Milburn Violette	Milburn	1	27	26S	28E
	Western Exploration Co.	Hyde	1	32	26S	28E
Round Mountain	Brown-Saffold Drilling Co.	Newberry	2	32	28S	29E
	Shell Oil Co.	Freeman	20	20	28S	29E
Canal	Shell Oil Co.	Canal A	47–14	14	30S	25E
Coalinga	Leo F. Jarvis		2	14	20S	14E
	The Superior Oil Co.	Coalinga Fee	2	7	20S	16E
	The Progressive Oil Co. of Coalinga, California		3	20	19S	15E
Humboldt Co.	George F. Sproul	Sproul Creek	1	34	4S	3E
Santa Fe Springs	The Texas Co.	Baldwin	6	6	3S	11W
Los Angeles Co.	Richfield Oil Corp	Domingues Ext.	1	2	4S	13W
Kettleman North	Standard Oil Co.		76	7	22S	18E
		DEEPEN OR REDRILL				
Long Beach	W. O. Dye		1	30	4S	12W
	Macmillan Petroleum Corp.	Lough	1	24	4S	13W
	A. T. Jergins Trust		4	19	4S	12W
	General Petroleum Corp.	Jonah	3	30	4S	12W
Torrance	C. C. M. O. Co.	Torrance	51	14	4S	14W
	MacDonald and Burns	Moore	5	23	4S	14W
	General Petroleum Corp.	Poggi	1	25	4S	14W
	Pennsylvania Oil Co.	Lomita	1	23	4S	14W
Montebello	Brookline Oil Co.	Drake Comm.	1	2	2S	12W
	The Texas Co.	Baldwin	17	6	2S	11W
Playa Del Rey	Adolph Ramish, Inc.	Hunter	1	28	2S	15W
Buttonwillow Gas	Seaboard Oil Co. of Delaware	Whitaker	1	8	28S	23E
Midway	Honolulu Oil Corp.		9 & 19	4	32S	24E
Mountain View	Hogan Petroleum Co.	Foster Comm.	5	32	30S	29E
Coalinga	The Texas Co.		S-11	30	20S	15E
	The Texas Co.		61 & 48	6	20S	15E
	Standard Oil Co.	Continental	23	2	19S	15E
Midway	Murvale Oil Co.		9	10	32S	23E
	Tide Water Assoc. Oil Co.		6	22	32S	23E
Kettleman North	K. N. D. A.		8	18	21S	17E
		ABANDON				
Richfield	C. C. M. O. Co.		4-R	33	3S	9W
Los Angeles City	R. H. Alexander, Jr.	Alexander	14	..	...	....
Los Angeles Co.	Hogan Petroleum Co.	Burkhard	1	7	5S	13W
Santa Fe Springs	Wilshire Oil Co., Inc.	Wilshire-Buckbee	2	6	3S	11W
	Wilshire Annex Oil Co.	Crawford	2	6	3S	11W
	Wilshire Oil Co., Inc.	Wilshire Crawford	2	6	3S	11W
Monterey Co.	The Texas Co.	F. L. Lewis	1	13	19S	5E
Mesa	Anacapa Oil Corp.	Low	5	28	4N	27W
Lost Hills	California Lands, Inc.	Occidental	1	24	26S	20E
Kern Co.	Geo. W. Johnson	Brown-Pallette	1	33	29S	30E
	Sierra Slope Oil Co.	Michaels	1	25	26S	28E
	Garner Bros. Oil Co.	Garner	1	6	27S	29E
Long Beach	The Texas Co.	Yochem	3	20	4S	12W
	W. O. Dye	Dye	7	24	4S	13W
Bardsdale	Monticello Oil Co., Ltd.	Bardsdale	10	12	3N	20W
San Luis Obispo Co.	I. Lee Burch		1	4	10N	26W
Midway	The Texas Co.	Thornber	5	34	31S	24E
Wasco	Continental Oil Co.	Seaboard-Associated KCL	C-1	26	27S	24E
Fruitvale	Sandy Oil Co.	Sandy	2	26	29S	27E
Tulare Co.	Dan Sheppard and Assoc.	Dan Sheppard and Assoc.	1	35	22S	27E
Mt. Poso	W. P. W. Petroleum Co.	Glide	1	19	26S	28E
Coalinga	Shell Oil Co.		17	17	19S	15E
	Shell Oil Co.		21	34	19S	15E

Summary	Week Ending Nov. 19	Previous Week	To Date This Year	To Date Last Year
Total New Wells	18	21	1033	1436
Total Deepened or Redrilled	10	12	696	613
Total Abandoned	11	12	453	463

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Field Development

San Joaquin Valley

Ohio Discovery Well Is Light Oil Producer

Living up to its formation test preview, Ohio Oil Co.'s Cole's Levee discovery well, KCL F-1, was completed on Armistice Day as an excellent producer of light oil. This seventh new field developed on property of Kern County Land Co. in less than three years promises to equal the high standard set by Ten Section, the first of the group brought in during 1936.

Completed, appropriately enough, on a national holiday, KCL F-1 flowed at the rate of 720 bbls. daily of 44.5 gravity clean oil together with nearly 4,000,000 cu. ft. of rich gas. Mechanically, the well is finished with a 7 in. casing cemented at 9220 ft., the top of the oil sand, and with 170 ft. of 4¼ in. liner, including 139 ft. of perforations, landed on bottom at 9365 ft. Shut in to conform to the valley curtailment program, present production is 236 bbls. of oil and 973,000 cu. ft. of gas.

Production coming from the Stevens zone of the upper Miocene series, it is probable that with greater penetration more oil sands will be opened, resulting in completions with a more satisfactory gas-oil ratio. In the neighboring Ten Section and Canal fields Stevens zone wells flow as low as 500 cu. ft. of gas per bbl. of oil. With an eye to producing more oil with less gas depletion, the Ohio Oil Co. is seriously considering deepening its discovery well.

Epco, Near Union

Epco, Inc., operating unit for Eureka Petroleum Co., has reached a depth of 2000 ft. in its wildcat well near the town of Union in San Luis Obispo county. The company has not yet reported any oil showings.

Hogan Completes Mountain View Well

Obtaining an initial flow of 350 bbls. of 26.7 gravity clean oil, Hogan Petroleum Co. recently brought in its No. 10 well on the Wharton lease in Sec. 32, 30-29, Mountain View field. Drilled to 5100 ft., the hole was plugged to 4983 ft. where a liner was landed which contained perforations below 4825 ft. The original bean of 20/64 in. has been reduced to 14/64. cutting production to 320 bbls.

At the south tip of the field in sec. 9,31-29, P. H. Greer redrilled his Perrel No. 2 to 6323 ft. and recompleted for 100 bbls. cutting 30% on the pump.

SAN JOAQUIN VALLEY WILDCATS

Area	Well	No.	Section	Depth	Status
	Fresno County				
Coalinga	American Oil Fields, Inc.	1	16, 19-15	250	Idle
	Jarvis, Leo P.	2	14, 20-14	50	Drilling
	Progressive Oil Co.	3	20, 19-15		Rigging up
	Stuart Oil Co., Stuart	1	12, 21-14	920	Drilling
	Tide Water Assoc. Oil Co., Fleishacker	1	1, 19-15	6430	Drilling
Clovis	Central Valley Oil Co.	1	1, 12-20	608	Idle
Jacalitos Hills	Dauphin Dev., Ragan	1	30, 21-14	4350	Drilling
Mendota	Pierce, Cyrus, Shorb	1	16, 14-12	1375	Drilling
	Kern County				
Belridge	General Pet. Corp., St. Helens	2	12, 28-20	1388	Testing
Buena Vista	Ohio Oil Co., KCL	A-8	32, 31-26	11186	Idle
		F-1	10, 31-25	9365	Flowing
Buttonwillow	Calif. Explor. Co., Salisbury	1	7, 29-24	8592	Drilling
Canal	Shell Oil Co., KCL	B-87	4, 30-25	9621	Drilling
Devils Den	Gibson Oil Co., Alferitz	3	14, 25-18	1230	Testing
	Goodrum, Geo., Baron	1	24, 25-18	1210	Idle
Dominion	Master Pet. Co., U. S.	1	34, 26-28	825	Idle
	Pottenger, F. M., Villard	1	2, 26-28	569	Abandoned
	Sierra Slope Oil Co.	1	25, 26-28	965	Abandoned
Edison	Johnson, G. W.	B-P 1	33, 29-30	1320	Abandoned
	Renner & R.H.L. Oil Co.	1	27, 30-30	2275	Drilling
Elk Hills	Richfield Oil Corp., Tup.	W 1	32, 30-25	8535	Drilling
Famosa	Shell Oil Co. KCL	A-58-8	8, 27-26	8580	Drilling
Fruitvale	The Texas Co., C.W.L.	1	7, 29-27	10122	Redrilling
Grapevine	Petrol Corp., Reserve	33-5	33, 11-19	6988	Idle
	Richfield Oil Corp.	KCL-1	28, 11-20	8325	Drilling
	Tidewater Assoc. O. Co.,S.P.	2	15, 11-19	2181	Drilling
	McVan Barnhart-Morrow Cons.	1	34, 27-27	410	Drilling
Mt. Poso	Federal Drilling Co.	4	13, 26-27	1392	Drilling
	Violette, Milburn	1	27, 26-28	280	Drilling
	W. P. W. Pet. Co., Glide	1	19, 26-28	1951	Abandoned
Midway	Fried, Julius	1	34, 32-24	4600	Drilling
Strand	Continental Oil Co.	E-1	17, 30-26	8575	Testing
Union Ave.	Richfield Oil Corp.,Union Ave.	1	6, 30-28	7930	Drilling
	Tulare County				
Terra Bella	Sheppard et al	3	35, 22-27	956	Abandoned

Valley Floor Test Progress Reported

Recent discoveries by Ohio Oil Co. and Richfield Oil Corp. in the Elk Hills-Buena Vista Lake area have stimulated to a high pitch interest in other valley floor wildcats.

Shell Oil Co. B-87-4 finding only stringers of oil sand at 8975 ft. in the Stevens zone, has set a 9⅝-in. string at 9621 ft. preparatory to prospecting ahead for the Vedder sand. The well is located in sec. 4, 30-25, two miles northwest of the Canal field.

Searching for deep oil production near the Buttonwillow gas field, California Exploration Co., Salisbury No. 1, sec. 7, 29-24, is below 8600 ft., having encountered only gas showings to date.

Finding the Vedder zone barren in its KCL A-58-8, sec. 8, 27-26, near Famosa, Shell Oil Co. is drilling ahead below 8575 ft. with the possible intent of locating the basement.

The Texas Co.'s Camp-West-Lowe No. 1, located in sec. 7, 29-27 northwest of Fruitvale, is fishing drill pipe at 8500 ft. after once attaining a depth of 10,122 ft.

Re-entering the McClung area south of Greeley, Superior Oil Co. is drilling KCL No. 12, its third prospect hole in sec. 3, 30-26. KCL No. 9, drilled a year ago, appeared for a time to have discovered a new oil field at 7600 ft. but on final tests proved a failure. No. 10 encountered no oil sand at all. As the Rio Bravo (Vedder) zone has since been shown to be productive at Greeley, it is probable the new well will be taken to that horizon.

Continuing the quest for production in the Grapevine area, Tide Water Associated Oil Co. has spudded its S. P. No. 2 in sec. 15, 11-19, three miles north of the Reserve play.

In the Strand area, Continental Oil Co. is continuing attempts to obtain production from KCL No. E-1 in sec. 17, 30-26. The hole has been redrilled to 8187 ft. where tests are being conducted.

Richfield's Union Ave. No. 1, sec. 17, 30-28, is drilling below 7900 ft. in hard shale with occasional streaks of sand.

Wolverine Petroleum Co. is planning to drill a test well in sec. 17, 29-25, approximately six miles west of Greeley.

Union Completes 6th Rio Bravo Well

With an initial production of 2500 bbls. in 16 hours, Union Oil Co. completed its sixth well in the field it discovered only a year ago. With 233 ft. of the Rio Bravo zone open to bottom at 11,514 ft., the well was started flowing by "rocking" with gas, and the first gauges were made on oil produced through the casing, the tubing being shut in. Now flowing through a 10/64 in. tubing bean, production is 388 bbls. of 40 gravity oil and pressures are 1750 lbs. on the flow line and 1775 lbs. on the casing head.

Superior Oil Co. deepened Geisinger No. 1 to 11,480 ft. and recompleted flowing 1900 bbls. through an 18/64 in. orifice. The company's next producer will be Ruhl No. 3, located at the southeast extremity of the field. Casing has been cemented at 11,425 ft. and the well is drilling in oil sand.

Geo. F. Getty, Inc. is preparing to complete Ramsey No. B-3 after topping the sand at 11,386 ft.

Standard Starts Five In Midway-McKittrick

Starting two new wells at McKittrick and three at Midway, Standard Oil Co. reflects the renewed interest of oil men in the old west side fields. The two at McKittrick will offset Franco Western's recent 350 bbl. completion in sec. 8,30-22.

East Texas field tallies show 25,000 oil wells to date—and a $500,000,000 bill for drilling costs!

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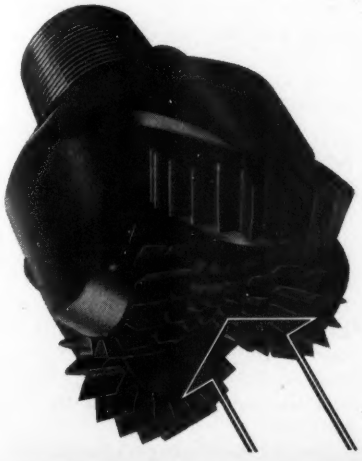

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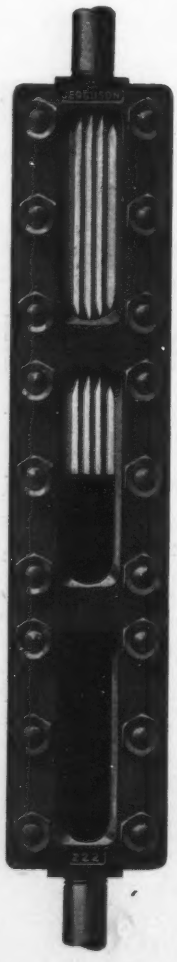
Standard Completes Big Wasco Producer

Completing Mushrush No. 1 as the second producer in the super-deep Wasco field, Standard Oil Co. obtained a flow of 6525 bbls. of 37 gravity clean oil on potential test. The well is an offset to Continental's discovery well, KCL A-2 and is located 330 ft. south and 330 ft. west of the east quarter corner of sec. 7, 27-24.

Bottomed at 13,139 ft., 7-in. casing was cemented at 11,579 ft. and a 4¾-in. liner, 1660 ft. in length and with the lower 40 ft. perforated, was landed at 13,138 ft. and cemented through perforations at 13,075 ft. The high yield of the well is remarkable in view of the small interval open. Immediately after the potential test, production was entirely shut in to conform with the field's curtailment practice of allowing an average daily flow of only 300 bbls. While shut in, tubing and casing pressures equalized at 1425 lbs.

While completing the big Mushrush well, Standard was abandoning an attempt to extend the field to the northwest quarter of sec. 17. KCL No. 8-B-1 was drilled to 13,716 ft. after topping the barren Wasco sand at 13,150 ft.

JERGUSON



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Also apparently destined for failure is Continental Oil. Co.'s KCL No. A-3 in sec. 8. Carried to 13,644 ft., the well has been plugged and tested by stages to 10,972 ft. but has shown only traces of oil.

Continental is preparing to drill No. A-4 near the southwest corner of sec. 8.

Test Gatchell Thickness In East Coalinga Eocene

With the intent of determining the full thickness of the Gatchell sand, Robert S. Lytle, operator of the former Petroleum Securities properties, is carrying well No. 31-18F down as long as oil sand is encountered. Since topping the zone at 6958 ft., more than 400 ft. of the rich "brown sugar" sand has been cored, the last reported depth being 7376 ft. The well is located in sec. 18, 20-16, half a mile east of Gatchell No. 2 which discovered the field. Greatest previous penetration was 327 ft. in Standard Oil Co.'s No. 82-13C in sec. 13, 20-15, which bottomed at 7112 ft. Lytle's No. 88-7F, drilling in oil sand below 7790 ft. will be carried as deep as warrented by the findings of No. 31-18F. No. 88-7F topped the sand at 7700 ft., shallower than expected as it is located in the southeast corner of sec. 7 offsetting Superior Oil Co.'s Hight No. 1.

Superior Oil Co. is spudding its interesting semi-wildcat, Cagle No. 1, near the south quarter corner of sec. 6, 20-16. If successful, the well will extend production nearly a mile to the north. Superior's Coalinga Fee No. 2 is drilling in the hard Kreyenhagen shale at 6000 ft.

Standard Oil Co. is preparing to drill 1-17F in the northwest corner of sec. 17, an offset to Lytle's No. 88-7F.

Mortality High In Shallow Tests

The mortality rate continues high among east side wildcats, five of which have been recently abandoned.

The Geo. W. Johnson well on the Brown-Paulette lease in sec. 33, 29-30, east of Edison is said to have been stopped in schist at 1320 ft. The project has worked intermittantly for the past year.

Dr. F. M. Pottenger encountered the granite basement rock at 565 ft. and abandoned his Villard No. 1, Dominion area test in sec. 2, 26-28. In sec. 19 of the same township, W.P.W. Petroleum Co. gave up Glide No. 1 at 1950 ft. after penetrating 30 ft. of the barren Vedder zone.

Sierra Slope Oil Co., Micheals No. 1, sec. 25, 26-28, stopped in granite at 965 ft. Sheppard & Associates abandoned their Terra Bella well at 956 ft.

Richfield Deepens Tupman-Western 1

Formation tests having revealed Tupman-Western No. 1 as the discoverer of another deep valley floor oil field, Richfield Oil Co. is coring the project ahead to open the black oil sands believed to underlie the rich wet gas horizon proved between 8406 and 8523 ft. Identified as the Stevens zone, it is probable that a further penetration will result in large production of oil under 40 gravity with a favorable gas-oil ratio.

No tests have been made since cementing 8⅝ in. casing at 8406 ft. Locations of this well and Ohio's KCL F-1 are plainly shown on the map published in the first November issue of the California Oil World.

Amerada, Texas Abandon Northern Wildcats

Encountering rhyolite, Amerada Petroleum Corp. abandoned its Colusa county test, California Lands No. 1, at 8152 ft. Although formation tests were made of all possible horizons, recovery was only mud and salt water in every case. The well was located in sec. 34, 16n-1w, five miles southeast of Colusa.

The Texas Co. found no encouragement to 4537 ft. and abandoned its Monterey county well, Lewis No. 1.

Richfield Oil Co. is attempting to complete its Potrero Hills No. 1 as a gas well at 3250 ft. The well seeks an extension of the Rio Vista field.

Belridge Oil Gets Two Large Producers

Two large producers were recently obtained by Belridge Oil Co. on its extensive holdings in the North Belridge field. Well No. 19 in sec. 27 was finished at 8480 ft. with a flow exceeding 2600 bbls. of 30 gravity oil and 1,600,000 cu. ft. of gas. Well No. 31 in the same section bottomed at 8450 ft. and came in for 2350 bbls. with 2,500,000 cu. ft. of gas.

Edison Well Flows 200 Bbls.

Wood-Callahan Oil Co. completed sec. 21 Comm. No. 3 at 3570 ft. with a flow estimated at 200 bbls. of 18.5 gravity oil cutting 8.0%. The liner is perforated at intervals below the water string shoe at 3350 ft.

In sec. 5, 30-29, Francis O'Reilly is testing for production after deepening the old Berree Petroleum Corp., Edison-Seal No. 5 and plugging back to 2510 ft.

Wells Active Near Coalinga

With one exception, Fresno county wildcats are confined to the area adjacent to Coalinga. Most important of them all is Tide Water Associated Oil Co.'s Fleishacker No. 57-1 in sec. 1, 19-15 which is strictly a "no dope" hole on everything except depth. At 6429 ft., observers reported the well reaming.

Progressive Oil Co. of Coalinga, backed by El Monte capital, is spudding a test of sec. 20, 19-15 near where Shell recently abandoned Coast Range No. 21 after drilling to 2244 ft. A formation test in the latter well at 1200 ft. recovered only gassy mud.

At the outskirts of the old Coalinga Westside field, Leo F. Jarvis is drilling well No. 2 at 125 ft. Location is in sec. 14, 20-14. Stuart Oil Co., operating in sec. 12, 21-14, is said to be running casing after drilling 920 ft.

Six miles west of Coalinga production, Dauphin Development Co. is drilling its second Waltham Valley test, Ragan No. 1, below 4350 ft.

Outside of the Coalinga area, Cyrus Pierce is drilling Shorb No. 1 at 1400 ft. in sec. 16, 14-12 near Mendota.

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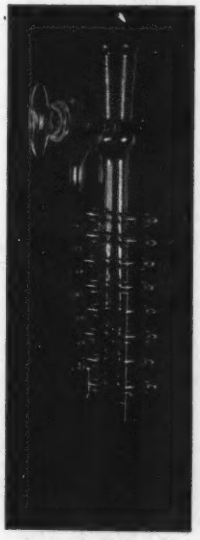

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Los Angeles Basin

De Soto May Prove Signal Hill Deep Zone

Promising new life for sleepy old Signal Hill, De Soto Oil Co. is preparing to make one of the most momentous tests in the field's history. Having cored alternate streaks of shale and oil sand from 9750 ft. to bottom at 9925 ft., the operators set 7-in. casing at 9746 ft. and after testing the water shut off are said to be cleaning out to try the open interval with a formation tester. According to R. W. (Rocky) Jerman, company president, plans may be changed at the last minute, however, and more cores taken.

Beyond question of a doubt De Soto No. 1 is at the present time the most important well in the entire state as a large completion would reopen the most closely drilled townlot field in the world. Most engineers believe the well has an excellent chance for production and if the deep zone compares in productivity with the older horizons, the yield should be large.

In the seventeen years of its productive life, the Long Beach field has produced over 600,000,000 bbls. of oil averaging 25 gravity. With 1350 acres proved, the average recovery per acre is nearly half a million barrels. Although many wells have been abandoned, approximately 1250 are yet producing 54,000 bbls. daily. Unusual thickness of sand is found in this field, the present productive interval being between the 2300 and 8500 ft. levels in both Pliocene and Miocene formations. Deepest previous test was Shell Oil Co.'s Nesa No. 11, drilled to 9280 ft. during the "deep zone" campaign of nearly ten years ago. As controlled drilling was not developed at that time it is probable that the hole drifted down structure.

Wilmington Awaiting L. B. City Operations

Awaiting action of the city of Long Beach on its contemplated 100 well drilling program, the Wilmington field is at a low point in drilling activity with only 15 "digging". Only completions of late have been by the field's largest operators; General Petroleum Corp. finishing S. P. No. 2 for 1100 bbls. and Harbor Community No. 28 for 585 bbls. while Union Pacific Railroad brought in two totalling 1250 bbls. and Universal Consolidated Newport No. 3 flowed at the rate of 1000 bbls.

Total field production remains close to 95,000 bbls. exceeding its allotment by more than 25,000 bbls. a day.

Basin Enjoying Period of Intense Wildcatting

More exploratory wells are working in the Los Angeles Basin than at any time since the lean days of the early 1930s. Joining in the search for black gold are companies, partnerships, and individuals with financial ratings from a minus zero to the largest units in the world industry. Though the ratio of discoveries per well has not been very favorable, one new field, at least, has more than paid for the exploration work of many years. Not since the hey day of Signal Hill, Huntington Beach, and Santa Fe Springs has there been a new field to equal that developed at Wilmington during the last two years. In hopes of duplicating General Petroleum's notable discovery, oil men, great and small, are bending their efforts toward uncovering another of the Basin's famous, prolific and longlived bonanzas.

Among the most interesting are the two wells drilling near the Athens-Rosecrans field. Western Gulf Oil Co.'s Bagg No. 1, located half a mile east of production on Rosecrans Ave., has passed the 7000 ft. marker and is the cause of much speculation as no information regarding formations has been released. East of the north end of Athens, W. E. Entrikin, Trustee, has spudded "D" 1 at the intersection of 120th and Main streets. As both gas and oil showings were encountered in an old well drilled in this area to relatively shallow depth, protection acreage is said to command a good price.

A pronounced revival of interest has taken place in the general vicinity of Newhall, birthplace of the industry in California. Tide Water Associated's Porter No. 1, discoverer of the new Aliso Canyon field, is beaned back to 225 bbls., the oil being very clean and of 24 gravity. Barnsdall Oil Co. is drilling in oil sand below 6500 ft. in Rancho San Francisco No. 4, while the first three wells are held to their small allotted rates. Royal Land Corp. has overcome caving hole troubles in its Castail test well and reports gas and oil showings at 1250 ft. Mangrum & Page have spudded in a cable tool well on the Lintz lease in sec. 4, 3-15, east of Newhall. Newhall Drilling Associates are redrilling the old Southern California Drilling Co. Needham No. 4 in sec. 13, 3-16. In sec. 20, 4-17, Continental Oil Co.'s core hole is now below 2100 ft.

Between Dominguez and the Long Beach field, Richfield Oil Corp. has made

LOS ANGELES BASIN WILDCATS

Area	Well	No.	Section	Depth	Status
Athens	Entrikin, W. E.	1	7, 3-13	1800	Drilling
Bellflower	Clayton, Geo. L., Scott	1	32, 3-12	6897	Idle
Castaic	Royal Land Corp.	1	8, 4-17	1245	Drilling
Dominguez	Richfield Oil Corp.	1	2, 4-13	4510	Drilling
La Mirada	DHB Oil Co., Heath	1	34, 3-11	6150	Idle
	John McKeon and Assoc. Carmenita	1	21, 3-11	8965	Drilling
Mojave	Mojave Pet Co., Gorman	1	5, 8-18	450	Drilling
	Jennings	2	33, 5-14	260	Drilling
Newhall	Continental Oil Co., Newhall	1	20, 4-17	2095	Drilling
	Mangrum and Page, Lintz	1	4, 3-15	65	Drilling
	Newhall Drlg. Asso., Needham	4	13, 3-16	3505	Cleaning out
	Palmluck Oil Co.	1	23, 3-16		Rig
Palmdale	Antelope Valley Pet.	1	17, 6-12	1900	Idle
Palos Verdes	Gene McLaren	1	27, 4-14	3992	Idle
	Rolling Hills Pet.	1	27, 4-14	5100	Idle
Santa Monica	The Texas Co., A-S	1	9, 2-15	6303	Drilling
San Pedro	Grady, R. T.	1	23, 5-14		Rigging up
	Hogan Pet. Co., Burkhard	2	6, 5-13	2300	Drilling
Whittier	Langstaff, Geo. W., Iliff	1	8, 2-11	2250	Idle
	H. C. Oil Co., Joyce	1	22, 2-11		Location
	Orange County				
Bolsa Chica	New Fields Oil Co.	1	16, 5-11	4100	Idle
Corona del Mar	Shell Oil Co., Irvine	1	6, 7-9	750	Drilling
Costa Mesa	A. V. Oil & Gas Co.	1	16, 6-10	4751	Testing
	San Bernardino				
Carbon Canyon	Carbon Canyon Oil Co.	1	30, 2-8		Rigging up
Chino	So. Counties Pet.&Drlg. Co.	1	26, 2-8	2300	Drilling
	San Diego County				
Carlsbad	Dauphin Dev. Co.	1	16, 12-4	820	Drilling

nearly 5000 ft. of hole in its Dominguez Estate No. 1.

Of the two wells drilled by the McKeon brothers, one, the New Fields Oil Co. well at Bolsa Chica, is idle at 4100 ft. while the other at Carmenita, is drilling close to the 9000 ft. level. The latter project has had oil and gas showings in the last 100 ft., according to John McKeon.

In the San Pedro-Palos Verdes area, Hogan Petroleum Co. is estimated to be down 2300 ft. in its second "no dope" test of the Burkhard lease. R. T. Grady is preparing to spud his well located on the high point back of San Pedro and E. C. McClaran reports his Rolling Hills well will soon set casing near bottom at 5100 ft.

Treasure Oil Co. is testing for production after setting casing at 6135 ft. in its 6511 ft. Playa del Rey outpost.

The Texas Co., usually free with information, has emulated the well known clam regarding its AndersonSpring No. 1 at Santa Monica. Depth of the hole is about 6500 ft.

Adjoining the Whittier College campus, Heffern & Cathriner are preparing to drill to the old shallow sands.

The Costa Mesa test of A. V. Oil & Gas Co. is attempting to develop production from sand streaks cored near bottom at 4751 ft.

Starting what may develop into a many-well campaign, Shell Oil Co. is drilling a shallow core hole on the large Irvine ranch back of Corona del Mar. Equipment is light rotary similar to that used in prospecting the area between Richfield and Yorba Linda where the company is spudding Dunford No. 1 at the intersection of Oriente and Ohio streets.

Besides those in the Los Angeles Basin proper, several wells are drilling in widely scattered areas. Neu-Cal is drilling below 1050 ft. in the Antelope Valley, while near Gorman, Mojave Petroleum Co. has a test approaching 500 ft. The latter company is also drilling Jennings No. 2 near Mint Canyon below 260 ft.

In San Diego County, E. A. Hargraves has passed the 3000 ft. point, Palm City Oil Co. is reported to have spudded in, and Dauphin Development Co. is below 800 ft. near Carlsbad.

Coast Consolidated Co. is reported as planning immediate drilling in the Dana Point area.

Carbon Canyon Oil Co., Southern Counties Petroleum & Drilling Co., and E. F. Stella all have projects working in the Chino area of San Bernardino county.

Asphalt highways at $10,000 a mile are cutting the costs of heavy-duty roads by more than 50%.

Royalty Service Extends Production in Rosecrans

Extending deep Rosecrans production to the west bend in Main St., Royalty Service Co. brought in Gordon No. 2 flowing 1400 bbls. of clean 31 gravity oil. Hole was bottomed at 7783 ft. and water is shut off with 8⅝-in. casing cemented at 7645 ft. Beaned to 40/64-in., present production is 1350 bbls. of oil and 2,000,000 cu. ft. of gas.

Another good well was finished by Barnsdall Oil Co. in Rosecrans No. 11, which, drilled to 7645 ft., came in at the rate of 700 bbls. per day. The cut in this project has been slow in cleaning up, the last reported being 10%.

Universal Consolidated's Trust No. 6, located 1200 ft. north of Rosecrans and west of Figueroa, was wet on a production test and has been recemented. Rig is up for No. 14 an offset to H. B.'s 600 bbl. well.

Recently started projects include those of Wilshire Oil Co. on the Leitch lease, Royalty Service Co., Gordon No. 2, J. L. O'Donnell No. 46 and Hydro Carbon Products Co. Cole No. 2.

New Zones Boost Montebello Reserves

Adding millions of barrels to the possible ultimate recovery of the west Montebello area, two new zones have been opened below former producing horizons. The higher of the two, the fourth finger of the Sixth zone, was cored but not tested in Hathaway Co., Dore No. 1, and was first produced by Herley-Kelley Oil Operations in their Masser No. 1, located 400 ft. south and 500 ft. west of the corner of Lincoln and Maple streets. The fourth finger was topped at 6625 ft. and was penetrated 65 ft. to 6690 ft. where the well was finished with a liner cemented through perforations at the top of the interval. Flowing through a 70/64-in. orifice, initial gauges were at the rate of 1700 bbls. Beaned back to 48/64-in., production was 1510 bbls. of 35.5 gravity oil with a water content of 1.5%. Flow pressure was 225 lbs., casing pressure 900 lbs., and gas was approximately 2,000,000 cu. ft.

The Hathaway Co. placed its Seventh zone discovery well, Dore No. 1, on production from a total depth of 7181 ft. flowing 475 bbls. of 35 gravity oil cutting from three to five per cent. Open to bottom is 145 ft. of shale and good oil sand. Virtually a semi-wildcat, the well extended the field south of Beverly Blvd. and west of Maple Ave. It is assumed this horizon will be more prolific higher on the structure.

Immediately following these import-

New Mexico Drilling Contractor reports:

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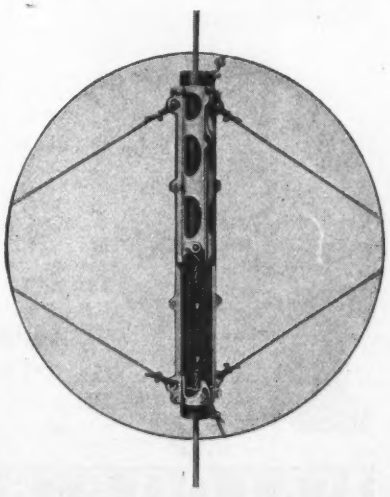

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ant completions, other operators began deepening, Montebello Reservoir Co. picking up the fourth finger at 6630 ft. and Standard Oil Co., Braun No. 3 entering the same horizon 10 ft. deeper. These wells should be on the completed list within a week. Among those heading for the new sands are V-8 Oil Co. M. B. No. 1, Pongratz Petroleum Co. Martin No. 1, Brookline Oil Co. Drake Comm. No. 1, and Montebello Wesco No. 1, all favorably located in view of present developments.

New entries in the field include Olympic Refining Co. with Smith No. 1 at the corner of Maple and Victoria, Seacliff Petroleum Corp. on the golf course, and Well Developers, Inc. on lot 172; the latter being a group of St. Helens employees.

St. Helens Petroleum Co., whose Monterey No. 20 was responsible for the new development, is completing Monterey No. 29 in the Fifth zone and Taylor No. 2 in the Sixth.

Apex Abandons Five Points Test

Another attempt to extend the small Five-Points producing area ended in failure recently when Apex Petroleum Co. abandoned its Harper No. 1 after coring only a few stringers of oil sand to 5436 ft. The well was located to the southeast of the Delaney and J. E. F. small producers. The latter company is preparing to complete its second well, Bruce No. 1 after bottoming at 4460 ft. and setting casing at 4360 ft.

Southwest Exploration Co. obtained its first tideland production from State No. 2 which was bottomed at 4255 ft. and finished pumping to the sump. State No. 1 was delayed by a fishing job but will soon be completed. Derricks have been erected for State Nos. 3, 4, 5, and 6.

Pace Slackening in Torrance Extension

A distinct slackening of pace has been noticeable in the southeast extension area of the Torrance field. Completions in the past fortnight numbered only five and the number of drillers dropped to eight. Initial gauges of the new production were all small, the largest being 350 bbls. obtained by Ring Oil Co. in its Hawkins No. 5. The well was, however, less remarkable for its yield than for its phenomenal drilling time; only a few hours more than 12 days from spudding in to flowing.

A mild feeling of hope has been aroused by rumors that R. R. Bush will make a schist test of Torino No. 1, now standing idle at 5575 ft. That Richfield considers the possibilities of the old upper zone in its easterly edge wells is evident in the facts that it was protected with cement in the first well and is being carefully cored in the second.

Balthis Reports Spurt In Mid-Continent, Gulf

B. D. (Doug) Balthis, of Natural Gas Equipment Co., Los Angeles, has just returned from a six-weeks' trip in the Mid-Continent and Gulf Coast areas

where he made valuable new connections to strengthen his sales organization in those lively areas.

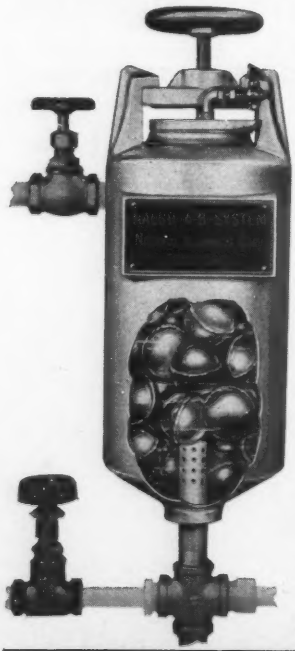
Mr. Balthis says he was struck by the volume of business available in the unusually active Mid-Continent and Coastal oil fields. While drilling and production work is noticably lagging elsewhere in the country, Mr. Balthis said that the Texas and Louisiana areas were bright spots which gave no indication of dimming soon.

While Mid-Continent sales of Natural Gas Equipment Co. will continue in the capable hands of Harry H. Cook, Mr. Balthis said, sales operations of the company in the Gulf Coast fields have been solidly established through connections with such organizations as Frick-Reid Supply Corp., and Houston Oil Field Materials Co.

Union Oil Employe Dies

T. C. Rutter, for many years an employe of the Union Oil Co. of California, died November 3.

Cuts Drilling Costs 30%



AT a cost of less than a dollar per boiler per day for chemicals and service, a prominent California oil company recently ran a 1752 hour drilling test using Nalco Feedwater Treatment for the drilling rig boilers. The total saving amounted to $7,666 which was equivalent to a 30% reduction in drilling costs.

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Coastal District

Drillers Are Active In Ventura County

Ventura county, at once the paradise and the graveyard of the small independent, is the scene of much widely scattered activity.

Near Ojai, High Mesa Oil Co., with bottom at 1750 ft., is repairing equipment to continue drilling and the Upper Santa Ana Oil Co. is planning to start work within a short time.

Four wells are drilling in the vicinity of Fillmore. Merchants Petroleum Co. has bottomed Cochrane No. 8 in oil sand at 1365 ft. and is reaming the hole. Claran Oil Co. is drilling at 1400 ft. in Hardison No. 1, Commander Oil Co. is attempting to sidetrack a cable tool bit at 575 ft., and St. Louis Oil Co. is at 1450 ft. with 8⅝ in. casing in the hole.

In the Shiells Canyon field The Texas Co. is preparing to complete well No. 135 at 4066 ft. and is building a rig for No. 136. El Rancho Oil Co. has a derrick for Elkins No. 2.

Section 20 Oil Co.'s Tar Creek test, Burge No. 2, is drilling in oil sand at 2350 ft.

On the Canet property near the Ventura Avenue field, Ventura Drilling Co. is coring below 1900 ft.

Lloyd Tests East Side of Ventura Avenue Field

Most interesting of all the wells in the coastal area is Lloyd Corporation's No. 2 located on the east end of the Ventura Avenue structure. Several hundred feet of fair-to-good oil sand are reported below 6400 ft. and 9⅝ in. casing has been cemented for a production test. Total depth is 7300 ft. but it is understood that the hole will be plugged to approximately 7000 ft.

British American Oil Producing Co. is drilling its first well on the Bolsa Chica Oil Co. Hartman lease, No. 7, and has made a location for another, No. 8.

Tide Water Associated Oil Co. leads in number of active projects in the field with a total of ten. Shell is working on three wells.

Oil Group, Inc., Starts Summerland Wildcat

Oil Group, Inc., has erected a derrick for an important test well in the outskirts of the town of Summerland, Santa Barbara county. The well will try for production in the Sespe beds which have shown encouraging amounts of oil in other test wells drilled in the vicinity. Oil Group, Inc., is a new organization of Los Angeles men headed by C. A. Doddy.

Litho to Drill Capitan Wildcat

Planning to test for production on the east flank of the Capitan field, Litho Oil Co. has erected a derrick for Rhode Island Estate No. 1, 150 ft. north of the State Highway and 150 ft. east of the General Petroleum Erburu lease. The new company is composed of Geo. Trithan, Anthony Pappopakis, and Sam Newman; all of Los Angeles.

Douglas-Stratton Renews Operations in Carreaga

After three months idleness, Douglas-Stratton Oil Co. has resumed operations and is deepening its Carreaga No. 1 in sec. 8,8-33. Work was suspended in August of this year when a production test at 6239 ft. resulted only in the recovery of water. Deepening, the well is now below 6650 ft. in hard brown shale.

Loma Grande Stops In Volcanic Rock

Encountering basalt at 1965 ft., Loma Grande Oil Co. has suspended activity at 2125 ft. in its Luis No. 1, exploratory well located near the city of Edna in San Luis Obispo county. Production tests of showings at 1475 ft. proved the shallow sands to be non-commercial.

NORTHERN COUNTIES WILDCATS

County	Well	No.	Section	Depth	Status
Colusa	Amerada Pet. Co.,Calif. Lands	1	34, 16-1	8152	Abandoned
Humboldt	Texas Co., Eureka	2	22, 3-1	7708	Redrilled 4864 Testing
Monterey	The Texas Co., Lewis	1	1, 19-5	4537	Abandoned
	Anderson, A. A., Hillman	1	15, 24-14	4004	Testing
	Tannehill. L. B., Quinn	1	35, 20-8	2250	Drilling
Sacramento	Superior Oil Co., R. B.	1	7, 3-3	3883	Gas Well
San Mateo	Wilshire Oil Co., Cowell	2	20, 6-5	1605	Producing
Solano	Richfield Oil Corp., Potrero	1	10, 4-1	5334	Testing
Stanislaus	Orestimba Oil Co.	1	12, 7-7	790	Idle

COASTAL COUNTIES WILDCATS

Area	Well	No.	Section	Depth	Status
Santa Barbara County					
Capitan	Litho Oil Co., Rhode I.	1	4, 4-30		Rig
Carreaga	Douglas-Stratton Oil Co.	1	8, 8-33	6650	Drilling
Foxen Canyon	Richfield Oil Corp., Tinaquaic	1	36, 9-32	1990	Drilling
Gaviota	Gaviota Oil Co., Hollister	1	35, 5-33	3215	Idle
Gato Ridge	Barnsdall Oil Co., Mag.	5	9, 8-32	3035	Idle
	Pezzoni	1	15, 8-32	4494	Testing
Lompoc	O'Donnell, J. E., Helen	1	8, 7-33	4998	Testing
Los Olivos	Continental Oil Co., La Laguna	2	25, 8-31	5520	Drilling
	General Pet. Corp., La Laguna	1	6, 7-30	3831	Idle
Orcutt	Warren Deuel, Garrett	1	12, 9-34		Rig
San Luis Obispo County					
Edna	Loma Grande Oil Co., Lewis	1	28, 31-13	2125	Drilling
Elk Horn	Calif. Pet. Prod. Co., Irons	1	19, 10-24	1710	Cleaning out
	Lee, Harry, Defiance	1	7, 32-22	225	Drilling
	Western Plains Oil Co.	1	7, 31-21	4010	Idle
Huasna	Hancock O. Co.,Scherer-Dickes	1	30, 12-33	5593	Idle
Paso Robles	Vanguard Oil Co., Clark	1	26, 27-14	4950	Idle
	Epco. Inc.	1	27, 26-13	2150	Drilling
Ventura County					
Ojai	High Mesa Oil Co.	1	16, 4-22	1750	Drilling
Red Mountain	Martin, J. W.	3	15, 4-21	1250	Idle
Sespe	Claran Oil Co., Hardison	1	22, 4-20	1390	Drilling
	Commander Oil Co.	7-F	13, 4-19	575	Redrilling
	Crystal Oil Co., Crystal	1	35, 5-20		Location
	McKinnis, Chas., Cosley	1	14, 4-19	1090	Idle
	Merchants Pet., Cochran	8	1, 4-20	1365	Drilling
	Speik Oil Co.	1	33, 5-19	3440	Idle
	St. Louis Oil Co.	1	1, 4-20	1440	Drilling
Shiells Canyon	The Texas Co., Shiells	135	4, 3-19	4066	Testing
South Mt.	Clipper Oil Co.	1	17, 3-20		Rig
Tar Creek	Section 20 Oil Co.	1	20, 5-19	2353	Drilling
Timber Canyon	Stallings, Senter, Ahlberg	1	24, 4-21	1445	Idle
Ventura	Ventura Drilling Co.	1	10, 3-23	1880	Drilling

Europe Large Market For Oil Well Equipment

"Europe is looking to America for the development of oil field equipment and methods," reports Walter T. Wells, president of the Lane-Wells Co. Mr. Wells has just returned from a two-months' visit to England and the Continent.

Walter Wells

During the trip Mr. Wells traveled through France, Belgium, Holland, Germany and Sweden and met executives of the major oil producing companies in those countries. The greatest interest, reports Mr. Wells, of European oil operators is the development of modern drilling and completion methods with the view of reducing production costs. Almost every square foot of Europe is being tested for possible producing fields and as a result, drilling operations are starting in localities heretofore thought to be barren. The outlook for American equipment manufacturers in foreign fields is particularly bright.

"With overseas prospects good for 1939 and a record year for 1938 in the United States the Lane-Wells Company plans an aggressive campaign for the coming year," according to Mr. Wells. "New field equipment is under construction, men are being trained and we expect 1939 to be the biggest year so far in the company's operations."

MacClatchie Liner Puller For Hard Surfaces Announced

A new type Liner Puller has been announced by MacClatchie Manufacturing Co., Compton, Calif., that is especially designed for pulling hard-surfaced liners, upon which, the manufacturers state, slip type pullers will not grip. This new tool, known as the "Universal", is built of steel, heat-treated to withstand severe usage, and is furnished in two sizes for pulling all sizes and makes of pump liners.

Operation of the Universal Liner Puller is extremely simple. The puller legs are mounted on a long bolt and are designed so that, when pushed through the liner, they automatically engage on the end of the liner. The yoke is then

adjusted over the cylinder head studs and simply tightening the combination nut places a strong, steady pull on the liner.

The tool contacts the inside of the liner only when the legs are being pushed through to the end for setting. It will in no way harm the finished surface of any liner—an important feature when pulling only partially worn equipment. The tool is equipped with a roller thrust bearing that reduces friction and permits easier turning. The threaded mandrel is unusually strong, and is heat-treated for additional strength.

Further information may be obtained by writing direct to MacClatchie Manufacturing Co., Compton, Calif.

To make the oil fields safe, employes of a petroleum company at Breckenridge, Texas, have carried on a snake-hunting drive which has resulted in the capture of some 3,000 snakes, chiefly rattlers.

Martin-Decker Announces Illuminated Weight Indicator

Martin-Decker Corp. has announced a new Weight Indicator, to be known as the "Special". This new instrument has many unusual features never before incorporated in a weight indicator, and

is particularly designed to handle extremely heavy loads, having 20% greater capacity than previous indicators. This feature, plus a supersensitive vernier indicator with a capacity of 100 points, insures sufficient capacity to handle wells deeper than any thus far drilled. The Special has an unusually large dial with built-in illumination that can be clearly read from all parts of the rig floor day or night. Ten interchangeable dials nested within the case give direct readings in **pounds** for all commonly used string-ups and line sizes. The center dial is graduated in weight and vernier points for the convenience of those desiring to use this system.

Two gauge hands—a regular gauge hand and a supersensitive one (six times as sensitive) enable the Special to cover all phases of drilling and production work with safety and high precision.

The entire unit is factory filled and sealed. It cannot leak, and requires no pumping up, no priming, and no attention of any kind. The use of light, tough alloys eliminates unnecessary weight and enables the Special to weigh only 60 pounds complete. Its compact construction and light weight eliminate any tendency for the instrument to swing on the deadline in rough drilling. Another important feature is the unitized leakproof case and shatter-proof rubber sealed dial glass which completely seals the instrument against water, rain and the elements.

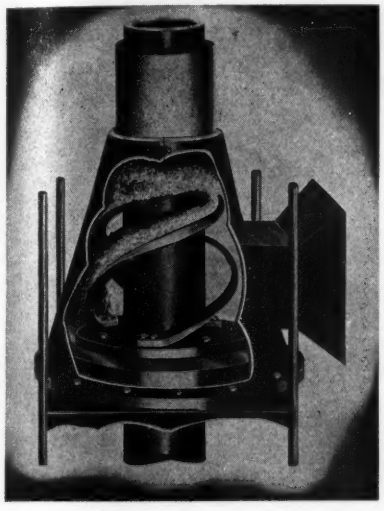
Complete information on the Special can be obtained by writing the Martin-Decker Corp., Long Beach, California.

Motorists pay more than $2 in gasoline taxes for every $1 paid for registration fees.

New Pipe Coating Process By American Pipe & Steel

Armor-Clad, a new process of coating pipe with cement or bituminous concrete, has recently been introduced by the American Pipe & Steel Corp. This unique method of application, by means of a specially designed, patented machine, now makes it possible to obtain a continuous, dense, uniform outer jacket which forms a perfect, seamless bond with the pipe, the makers say. This type of protective covering is intended to be permanently effective.

Armor-Clad is based on the theory that any properly prepared material can be made to adhere tightly to pipe if it is submitted to continuous rubbing pressure. However, such plastic materials must be of the proper consistency, similar to that of bituminous and concrete Armor-Clad formulas, to respond



to the spiral rubbing, troweling and tamping action that is the secret of the process. Coatings, after having been submitted to tremendous pressure, are held firmly in position by atmospheric pressure because of the intimate contact of steel and plastic, it is said.

Subjected to severe tests under the worst possible conditions, Armor-Clad has proven to be strong and durable; impervious to the destructive forces of corrosion, electrolysis, abrasion and soil stresses. In one case, a pipe that had 20% of its area completely rusted away was rehabilitated and made serviceable; its newly acquired mechanical strength supplied by massive concrete enabled it to successfully withstand pressures as high as 90 pounds.

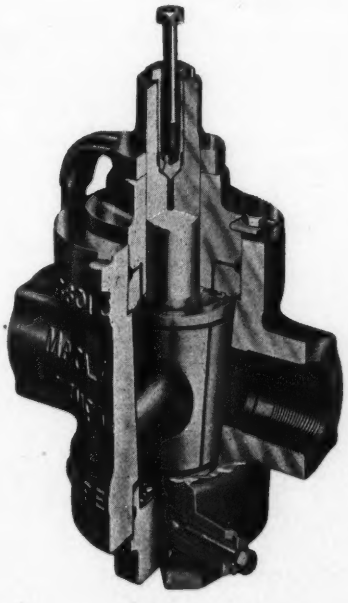
One of the most unusual, and vitally important, factors that contribute to Armor-Clad's economy of application, is that pipe lines can be coated in the trench without interruption of service in any way. The light steel construction of the machine facilitates its being taken into any territory, no matter how difficult the terrain. It is adjustable to various sizes of pipe and can apply coatings of thicknesses ranging from 5/8-inches to 2-inches. Easy removal of parts provides for the passing of obstructions and joints.

Armor-Clad incorporates many potential advantages and savings which establish this new process as a most important forward step in the everlasting fight to control ravaging natural forces. Every pipe line operator who has worried through years of heavy expenditures for maintenance purposes knows that profits have suffered proportionately.

Catalogs are ready for mailing to those who are interested in more complete details about Armor-Clad.

New Model MacClatchie Hydro-Seal Plug Valve

A revolutionary development in plug valve construction has been announced by the MacClatchie Manufacturing Co., Compton, Calif. This new model "Hydro-Seal" Plug Valve incorporates engineering advancements that eliminate packing troubles and make it leak-proof under all types of installations, the makers say. In fact, so perfect is the packing and sealing arrangement that one valve can be used interchangeably on chemical, gas, gasoline, oil or mud lines



with equal efficiency and dependability.

This new model MacClatchie "Hydro-Seal" Plug Valve is entirely grease packed. It has no metal, rubber, fabric or leather packing of any kind. Instead, two separate lubrication chambers, each equipped with the new "Lubricheck", permit positive thorough packing at all points where fluid might escape. Conventional type plug valves necessitate being torn down to replace packing, an operation that often requires shutting down operations at a critical time.

All the packing in this new MacClatchie Valve can be tightened or even completely renewed from the outside while the valve is working under high pressures.

Another important feature is the arrangement of the thrust bearings. By improved design the fluid pressure has been distributed so that it tends to push the plug down instead of up. This thrust load is carried upon a roller bearing assembly, adjusted to exactly balance the thrust pressure. Thus, the higher the pressure the tighter the seal, but the plug will neither freeze nor turn hard under high pressures because it rotates upon the specially designed thrust bearing.

The "Lubricheck" feature, mentioned above, is another MacClatchie development recently announced. It enables the grease chamber to be completely closed off while a new grease stick is inserted, thus permitting repacking the valve under high pressures without shutting down operations. This new model "Hydro-Seal" is "Lubricheck" equipped on grease as well as packing chambers.

Detailed information on this new MacClatchie Valve can be secured by writing direct to MacClatchie Manufacturing Co., Compton, Calif.

Yale & Towne Issue New Pump Booklets

The Yale & Towne Mfg. Co., Stamford, Conn., has just issued five interesting booklets describing their Tri-Rotor Rotary Positive Displacement Pumps. The following series numbers identify each booklet, the numeral indicating the number of gallons pumped per minute: 20C, 40A, 80B, 90C and 100C and the fifth booklet describes four Tri-Rotor Truck Pump Models pumping from 35 G.P.M. to 100 G.P.M. Each booklet presents performance curves for each pump operating on various fluids of widely differing viscosities.

The total value of the South's cotton crop, about three-quarters of a billion dollars, is not enough to pay the nation's annual gasoline tax bill.

Petroleum salesmen making their rounds in automobiles last year, hung up an enviable record of only one accident for each 97,115 miles traveled.

Business and Professional Directory

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Oil Men's Calendar

C.N.G.A. Meeting First Thurs. Each Month.

December

5-9—American Society of Mechanical Engineers, Annual Meeting, New York.

January, 1939

9-13—Society of Automotive Engineers, Annual Meeting, Detroit, Mich.

February

20-24—12th National Asphalt Conference auspices of The Asphalt Institute, Biltmore Hotel, Los Angeles.

March

22-24—American Association of Petroleum Geologists, Oklahoma City.

April

24-29—Oil World Exposition, Inc., Houston, Texas.

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Necessity and Application of Oil Well Surveys Shown

A clearly written and copiously illustrated booklet demonstrating the importance and economical advantage of drilling oil wells vertically and straight has just been issued by the Lane-Wells Co., 5610 South Soto St., Los Angeles. This bulletin will be sent to all who make request on their own letterhead. The following chapter headings indicate the scope of the publication: Reason for Making Surveys, Methods of Surveying Wells, Profitable Survey Applications, and Analysis of Various Types of Oil Well Surveys.